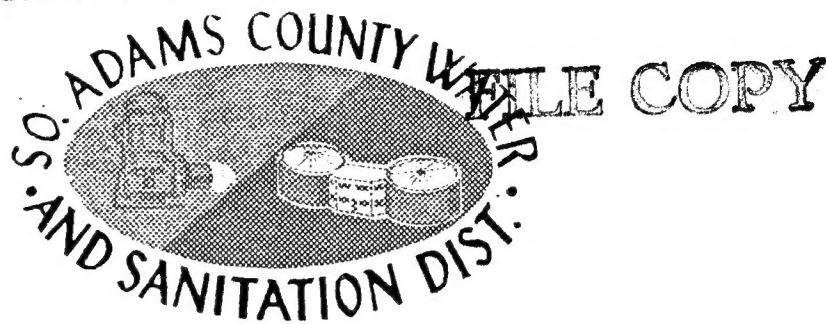


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TREATABILITY/FEASIBILITY STUDY
FOR
DISTRICT WATER QUALITY IMPROVEMENT

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JAMES M. MONTGOMERY, CONSULTING ENGINEERS, INC.



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April 28, 1986

Board of Directors
South Adams County Water
and Sanitation District
6595 East 70th Avenue
Commerce City, Colorado 80022

Subject: Treatability/Feasibility Study for
District Water Quality Improvement

Ladies and Gentlemen:

James M. Montgomery, Consulting Engineers, Inc. is pleased to submit this report on the evaluation of treatment alternatives for removal of organic ground water contaminants and for softening.

The conclusions and recommendations of this report are based on a preliminary review of blending, alternative surface water supplies, six organic removal treatment alternatives, and two softening alternatives. Costs are estimated for each alternative for treatment of the District's existing alluvial wells and for future potential alluvial wells. Costs are developed for both centralized facilities and decentralized facilities.

The feasibility of each alternative is evaluated with regard to the ability to provide reliable treatment in compliance with proposed State and Federal drinking water standards. In accordance with the requirements of the Colorado Department of Health, it is assumed that treatment would be required for Arsenal-unique organic contaminants for which there are presently no Federal standards. The recommendations further assume that the District would take a conservative approach to treatment of organic contaminants to ensure that, in addition to volatile organics, non-volatile organics would be removed should they occur in the existing alluvial wells in the future.

The two alternatives recommended for the District's consideration are Granular Activated Carbon Adsorption (GAC) and GAC with lime softening. Estimated costs and preliminary implementation schedules for these alternatives are presented in Chapter 7. A brief review is given in the Executive Summary.

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Board of Directors
South Adams County Water
and Sanitation District

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April 28, 1986

JMM appreciates the assistance received from South Adams County Water and Sanitation District during preparation of this report. In particular, Mr. Larry Ford, District Manager; Mr. Don Ramig, Assistant District Manager; Mr. Dave Brown, J.D., District Attorney; and Mr. Todd Gilmer, District Hydrogeologist; provided significant contributions.

We have enjoyed the opportunity to work with you and the District's staff on this interesting and informative project. Please do not hesitate to contact us should any questions arise.

Very truly yours,



William A. Tolle
Vice President

/vh

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WATER AND SANITATION DISTRICT**

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District Management

Larry Ford - Manager

Don C. Ramig - Assistant Manager

PROJECT STAFF

Engineering

William A. Tolle - Principal-In-Charge

Carol H. Tate - Project Manager

Richard L. Anderton - Project Engineer

Mark D. Umphres

Jeanne-Marie Bruno

Graphics

Ann J. Mancilla

Word Processing/Reproduction

Victoria A. Hubbard

Jack R. Bencomo

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EXECUTIVE SUMMARY

The South Adams County Water and Sanitation District's most productive shallow alluvial wells are contaminated with a number of volatile organic chemicals. In addition, previous and ongoing studies by various agencies have detected several nonvolatile organic contaminants clearly associated with Rocky Mountain Arsenal (RMA) operations in the northern portion of the existing District area and throughout the western half of the area north and west of RMA. This area is ultimately planned as an addition to the District's present service area.

The District retained the services of James M. Montgomery, Consulting Engineers, Inc. (JMM) to evaluate treatment alternatives for removal of organics contaminants and softening. The objectives of the study are outlined in the District's request for proposals dated October 11, 1985. In general, the objectives are:

- o To establish, through an analysis of cost and availability, potential sources of supply for the current and projected District water demands.
- o Based on requirements of the Colorado Department of Health and the Environmental Protection Agency, develop treated water quality goals.
- o Select the most feasible treatment for organic contaminant removal with consideration of cost, constructability and reliability in meeting treated water quality goals. The organic contaminant removal processes to be evaluated are air stripping, granular activated carbon adsorption, and granular activated carbon adsorption used in combination with air stripping.

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- o Determine the feasibility of blending contaminated water with other sources to meet treated water quality goals.
- o Recommend a softening alternative as an additional cost to organic contaminant removal.
- o Estimate the cost and implementation schedule for the selected treatment processes.

The Scope of Work to accomplish these objectives was specified in an agreement dated December 30, 1986.

Concurrently with this study, JMM assisted the District in evaluating emergency treatment facilities for the 77th & Pontiac, 77th & Quebec and 64th & Quebec street wells. The results of this evaluation are not discussed in this report since this effort was outside of the scope of work for this Treatability/Feasibility Study.

CHAPTER 2 - EXISTING FUTURE POTENTIAL WATER SUPPLY

The District currently has limited entitlement to three sources of supply: deep wells from the Laramie-Fox Hills and Arapahoe Aquifers; shallow, alluvial, wells; and Burlington ditch water. These sources of supply and future potential sources are reviewed with regard to historical use and use as a supplemental source.

Projected water demands for the District were reported in a recent water and sewer master plan (JMM, 1985). The current average and peak day demands are 4.1 and 10.2 mgd, respectively. The ultimate projected average day and peak day demands are 17.3 and 43 mgd, respectively.

About 85 percent of the District's demand is met from nine shallow alluvial wells. Seven of which have independent decreed flows. Two wells serve as alternate points of pumping for decreed flows. One of the wells is used

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exclusively at the District's wastewater treatment plant. The total decreed flow for the District's alluvial ground water supply is about 12.5 mgd. The actual present capacity is approximately 10 mgd. The District also utilizes an average of 0.54 mgd of deep well water. Under Senate Bill 5, the District may be able to increase this capacity by 0.2 to 0.6 mgd. Through the Duggan and Burlington-Wellington rights, the District has available 0.9 mgd of currently leased surface water supply. Based on the present decreed flows, another 30 mgd of capacity is needed to meet the District ultimate demand.

A recent study (Spronk, 1986) evaluated alternative future potential sources of water for the District. The purchase of shares in the Burlington, Wellington and FRICO Companies could provide the District with an additional 4.7 mgd firm transferable yield for this surface water supply.

Participation in the Metropolitan Water Development Agreement (MWDA) was evaluated with regard to cost and availability. To participate in this agreement, the District would have to purchase the subscription of an existing participant. There are no known existing participants willing to sell their subscription. Moreover, existing participants have priority over nonparticipants to purchase available shares. Several existing participants have expressed an interest in acquiring additional shares. In addition to the apparent unavailability of shares, there may be delays in Platte and Colorado River Storage Projects Participating Agreement (P&CRSPPA) which adds uncertainty to the initial delivery of project water.

The District is in the process of evaluating provisions for additional deep and shallow well water supplies to meet ultimate demand. The tentative proposal for 21 alluvial wells located at four general areas in the potential future District area would add about 31 mgd of capacity over the next 35 years. Additional deep wells would be installed in the existing District area and throughout the potential future District area to supply demands of customers.

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A comparison of the cost of the four potential future sources of supply indicated that deep and shallow ground water was significantly less expensive than Burlington ditch or MWDA water. Water costs included the cost of purchasing shares, well development and approximate treatment and supply costs. Approximate costs are summarized in the following table.

<u>Source</u>	<u>Approximate Total Cost (\$/acre-ft)</u>
Shallow Alluvial Wells	250-350
Deep Wells	200-400
Burlington Ditch System	1,000-1,100
MWDA - P&CRSPPA	600-700

Because of the greater cost and unavailability of adequate capacity of the Burlington and MWDA supplies, only the ground water supplies are evaluated with regard to treatment alternatives.

CHAPTER 3 - WATER QUALITY AND REGULATORY REQUIREMENTS

Historical water quality and regulatory requirements for treated water quality with regard to organic contaminants are reviewed. In addition, mineral quality of existing and future wells is summarized as a basis for cost estimates for lime and sodium ion exchange softening discussed in Chapter 6.

In the Federal Register on November 13, 1985, the EPA published proposed maximum contaminant levels (MCLs) and final recommended MCLs for eight volatile synthetic organic chemicals (SOCs) (plus two by-products), four microbiological contaminants, inorganics plus proposals for mandatory filtration of surface waters and disinfection of ground waters. Of principal concern to the District is the MCL of 5 ug/l for trichloroethylene (TCE) since several of their most productive alluvial wells have shown TCE concentrations consistently greater than 5 ug/l.

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The State of Colorado through the Department of Health (CDH) has primacy to establish water quality standards which must be at least as strict as the EPA's MCLs. The CDH has indicated that EPA MCLs will be applied as standards for treated water quality for the District ground water supply.

While the CDH does not presently have specific water quality standards or MCLs for hazardous organic chemicals unique to the RMA, but which are not included in the recent EPA drinking water standards, CDH requires that the District provide treatment to reduce concentrations of Arsenal - unique compounds. This requirement implies a treated water goal of less than the detection limit for these Arsenal-unique compounds. The Army has reported a minimum detection level of 1.9 ug/l for Diisopropylmethylphosphonate (DIMP), the most frequently detected Arsenal-unique compounds found off-post in the future District area.

Based on historical water quality, the contaminants presently of greatest concern are TCE and DIMP. TCE contamination is largely confined to the existing alluvial wells. DIMP has been detected in many of the private and monitoring alluvial wells in the future District area.

The CDH indicated that Dimethylmethylphosphonate (DMMP), another Arsenal-unique compound, may be of concern in the future District area. The actual extent of contamination has not been clearly defined due to the relatively high minimum detection limits. Trace amounts of 1, 2-dibromo-3-chloropropane (DBCP) have been detected in alluvial wells mostly in the northern portion of the existing District area. The deep well water in the existing District area appears to be free of significant organic contamination.

The District's existing and future potential alluvial ground waters are classified as very hard, according to the U.S. Geological Survey Hardness Classification. Alluvial ground water hardness is in the range of 300 to 500 mg/l of which 60 to 100 mg/l is magnesium hardness. Total alkalinity is about 260 mg/l.

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The following treated water quality goals were assumed for evaluation of treatment alternatives.

TCE and other Volatile Organics	Less than the proposed EPA MCLs
DIMP and other Arsenal-Unique Compounds	Less than the Detection Limit
Total Hardness	80 mg/l as CaCO ₃

CHAPTER 4 - EVALUATION OF BLENDING TO MEET TREATMENT GOALS

This chapter evaluates the feasibility of blending different sources of water to meet treated water quality requirements for organic contaminants. Average distribution system-wide concentrations of TCE and DIMP are estimated for the existing District area and future District area, respectively.

Estimates are computed from flow-weighted approximate average and maximum concentrations expected for each well or well field and for present and potential deep well capacity. The lowest concentration of TCE is 7.7 ug/l assuming an annual average deep well flow of 575 gpm and approximate historical average TCE concentrations. Using assumed concentrations of 10 ug/l of DIMP for future potential well areas C and D, 0 ug/l for well area A and no well capacity for well field B, a blend concentration of DIMP within the future District area served only by these well fields, the estimated DIMP concentration is 4 ug/l.

This preliminary estimate indicates that blending alone does not achieve the treated water quality goals suggested in Chapter 3. Further, blending does not satisfy the CDH's requirement of treatment for Arsenal-unique compounds and is therefore not considered to be a viable alternative.

CHAPTER 5 - PRELIMINARY SCREENING AND EVALUATION OF ALTERNATIVES FOR ORGANIC CONTAMINANT REMOVAL

This chapter reviews alternatives for treating contaminated wells to meet EPA

Executive Summary

proposed MCLs and CDH treatment requirements. The following six alternatives are screened with regard to cost and feasibility.

1. No Treatment
2. Withdrawal from Selected Strata
3. Air Stripping
4. Air Stripping with Air Pollution Control
5. Granular Activated Carbon Adsorption (GAC)
6. Granular Activated Carbon Preceded by Air Stripping

The above alternatives are evaluated with respect to cost-effectiveness in meeting the treatment goals, reliability, environmental impact, aesthetic considerations and constructability. On the basis of this preliminary screening, three alternatives are selected for evaluation in greater detail. The three alternatives include:

- o Air Stripping
- o Air Stripping with Air Pollution Control
- o Granular Activated Carbon Adsorption (GAC)

Treatment costs are estimated for centralized and decentralized facilities for existing alluvial wells and future potential alluvial wells. Decentralization of the existing wells assumed treatment facilities at each well site, with the exception of the 77th and Pontiac/Quebec wells, for which it was assumed a single facility would be provided. Costs include piping from the wells to the central plant and, where appropriate, back to the well site for storage. Process costs are estimated principally from EPA cost curves with figures adjusted to reflect current Denver construction and operation and maintenance costs.

In terms of the total treatment unit cost, air stripping is estimated to be the most cost-effective (13 ¢/1000 gallons) and GAC adsorption is estimated to be the most expensive (66 ¢/1000 gallons).

Executive Summary

For air stripping, decentralized facilities are slightly less expensive than a centralized facility near the 77th and Pontiac/Quebec wells. Centralized facilities for air stripping with air pollution control and GAC are slightly less expensive than decentralized facilities.

In spite of the lower costs of air stripping for treatment of existing ground water supplies, it is recommended that a GAC be considered for both existing and future water supplies. The justification for this recommendation is:

- o Air stripping will not ensure effective removal of nonvolatile organics that may ultimately migrate into the ground water supply.
- o Granular activated carbon would provide a single treatment appropriate for treatment of existing and future wells. The District's operations staff would therefore be able to operate and maintain similar facilities. As a result, more reliable operation of the facilities would be expected.
- o GAC facilities would be less visible and aesthetically more attractive than air stripping facilities.
- o Granular activated carbon facilities could be sheltered in a architecturally treated building. Air stripping facilities, on the other hand, would require towers 30 or more feet high.
- o Potential environmental problems with air pollution are eliminated with GAC.

CHAPTER 6 - EVALUATION OF SOFTENING ALTERNATIVES

This chapter evaluates the feasibility of lime and sodium ion exchange softening for the District's existing and future water supply. Reverse osmosis (RO), a

Executive Summary

process normally used for demineralization, is considerably more expensive than lime or ion exchange softening. Further, because of the relatively high hardness of the ground water, conventional softening prior to RO may be required to prevent scaling and to achieve reasonable water recoveries.

Lime-soda ash with two-stage recarbonation is assumed for the cost estimates. This treatment scheme is conservative with respect to cost and design to meet the treated water hardness of 80 mg/l. A number of other treatment schemes are available, including split-stream treatment, single-stage softening or a combination of lime softening and ion exchange. The appropriate scheme can only be determined by a predesign level study which should take into consideration plant location, land availability, detailed sludge handling analysis, historical mineral quality, and optimal treated water hardness and pH. Ion exchange cost estimates are based on pressure steel vessels.

Costs are developed for both centralized and decentralized treatment facilities. Centralized facilities assume a plant located at either the 77th and Pontiac/Quebec Street wells or along 80th Street, central to the 77th Street wells and the future potential wells in area A (see areas noted in Figure 2-1). It is envisioned that this plant would be designed for 12 to 15 mgd to initially treat water from all existing alluvial wells. It would ultimately be expanded to about 30 mgd to treat water from the future potential wells in area A. A second central plant located at area C would treat water from areas B, C and D. Decentralized facilities have four plants to treat the existing alluvial wells and four plants to treat future potential wells in areas A, B, C and D.

Lime-soda ash softening is less expensive than sodium ion exchange for future centralized facilities. The estimated total treatment costs for centralized

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facilities are summarized below.

	Treatment Cost Summary (¢/1000 gallon)	
	<u>Lime-Soda Ash</u>	<u>Sodium Ion Exchange</u>
Existing Wells	86	72
Future Wells	53	65

A recent amendment to the EPA Primary Drinking Water Standards recommends an optimum level for sodium of 20 mg/l. Sodium concentrations in the alluvial water range from 100 to 140 mg/l. Softening alluvial water from an average hardness of 420 mg/l to 80 mg/l would increase the sodium concentration as follows:

<u>Treatment Process</u>	<u>Approximate Increase in Sodium (mg/l)</u>
Lime-Soda Ash	90
Sodium Ion Exchange	145

CHAPTER 7 - RECOMMENDED TREATMENT ALTERNATIVES

Based on the preliminary evaluation of the treatment alternatives presented in Chapters 5 and 6, two potential treatment alternatives are recommended for the District's consideration. One alternative to remove organic contaminants is granular activated carbon adsorption facilities without softening. The other alternative is to provide treatment facilities for lime softening combined with granular activated carbon.

Construction and O&M costs are presented for each alternative. The costs are developed from EPA water treatment process cost curves. The accuracy of the capital cost estimates is in the range of minus 20 percent to plus 30 percent of actual cost.

Executive Summary

The estimated costs of the two alternatives to treat existing and future potential alluvial wells are summarized below.

	<u>Flow (gpm)</u>	<u>Capital (\$1000)</u>	<u>O&M (\$1000/yr)</u>	<u>Unit Cost* (¢/1000 gal.)</u>
GAC ONLY				
Existing Alluvial Wells	8,680	5,600	710	66
Future Potential Alluvial Wells	21,670	11,000	1,600	56
GAC WITH LIME-SODA ASH				
Existing Alluvial Wells	8,680	11,200	1,270	124
Future Potential Alluvial Wells	21,670	21,400	2,860	104

*Unit costs assume 30 year amortization at 8 percent.

Preliminary implementation schedules are developed for facilities to treat the existing alluvial ground water supply. A minimum of 19 months is required for predesign, design, construction and startup of a centralized GAC facility. This assumes that shop-fabricated, steel vessels would be utilized. Another 5 to 10 months should be added if concrete gravity GAC filters are used. Approximately 37 months would be required for a combined GAC/lime-soda ash facility. The longer implementation schedule for a GAC/lime-soda ash facility is due principally to the extended design and construction period required for the more complex structures and equipment.

Predesign and possibly bench/pilot scale testing will be required prior to detailed design. The following should be included in the predesign level evaluations:

GAC ADSORPTION FACILITIES ONLY

1. **GAC usage rates.** These can be estimated from operational data from the temporary treatment system or pilot studies.
2. **The feasibility of District-operated centralized GAC regeneration facility.** The usage rate for the existing wells determined from Task 1 above, may not be adequate to justify a regeneration facility.

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However, the addition of further GAC facilities for future potential wells may justify a District operated regeneration facility.

3. **The performance of the interim GAC adsorption facilities.** These units should be examined for the potential of calcium carbonate scaling and with regard to the necessity of pre- or post disinfection.
4. **Potential sites for facilities.**
5. **Well pump capacities.** Identify modifications, if required, to achieve adequate flow. This investigation should be done in conjunction with the District's hydrogeologist and should take into account the seasonal variability in well yield.

GAC ADSORPTION/LIME SOFTENING COMBINED

1. Bench or pilot scale tests to determine the extent of removal, if any, of organics with lime sludge. This evaluation should specifically consider removal of DIMP, DECP and other less volatile organics with lime sludge. If it is determined that removal occurs, then issues involved in disposal of the sludge should be considered in detail.
2. Evaluate alternative lime softening processes and process units, including single-stage treatment, split stream treatment, lime softening in combination with sodium ion exchange, and lime recalcination.
3. Evaluate sludge dewatering alternatives.
4. Evaluate land availability and site requirements in conjunction with item 3.
5. Evaluate distribution system piping changes needed to provide water

Executive Summary

to and from the centralized plants. Examine the need for onsite clearwell storage. This analysis should look specifically at the option of either providing system storage at the treatment plant with effluent pumping to meet peak demands or redistribution of plant flow to existing system reservoirs with use of existing boosters for meeting peak system demand.

6. Evaluate distribution system hydraulics and determine the necessity for distribution system piping modifications if centralized storage is selected.

CHAPTER 1

CHAPTER 1

INTRODUCTION

BACKGROUND

The South Adams County Water and Sanitation District (SACWSD) is located north of the City of Denver and, in general, within an area bordered to the west by the South Platte River, and to the east by the Rocky Mountain Arsenal (RMA). The SACWSD receives about 80 percent of its water supply from shallow alluvial wells. SACWSD's most productive wells are generally located in the Commerce City, within 1,500 feet of the western boundary of the RMA. The hydraulic gradient of the shallow alluvial water is such that in the vicinity of the District's most productive wells water flows from RMA to the northwest toward the South Platte River.

The RMA covers over 6,880 hectares (17,000 acres). Originally purchased by the U.S. Government in 1942, the RMA served throughout World War II as a manufacturing site for toxic end-item products, and incendiary munitions. In 1947, portions of RMA were leased by Colorado Fuel and Iron Corporation for additional chemical manufacturing, principally pesticide and herbicide manufacturing operations which were later assumed by Shell. From 1953 to 1957, RMA was utilized for manufacturing of chemical agents. Munitions filling operations with these chemical agents continued until late 1969.

Since 1970, RMA has been involved in cleanup operations of the numerous on-post chemical waste disposal sites. Several physical and/or hydraulic barriers, some equipped with treatment systems, have been in operation along the west and northwest boundary of the RMA. The barriers were implemented to arrest further migration of alluvial ground water contaminants into off-post wells. At this time, measures have not been taken by RMA to treat ground

Introduction

water from off-post wells which were contaminated prior to the institution of containment barriers.

In addition to investigating RMA, the EPA is investigating contamination from potential multiple sources.

As a result of contamination of its most productive wells, the District has been forced to either shutdown wells or blend contaminated water with uncontaminated supplies to meet proposed Federal water quality standards. In an effort to resolve this situation, the District has undertaken several recent studies. The first and ongoing study is to identify the contaminants, areas of highest contamination, and temporal variability. This work is being performed by HRS Water Consultants, Inc. A second study, recently completed, examined alternative sources of water to meet the lost capacity of existing wells and projected future water demands as the District expands into the area to the north of its present boundary (Spronk, 1986).

This report constitutes the third study, the purpose of which is to evaluate treatment alternatives for existing and future potential sources of supply for the District.

OBJECTIVES

The specific objectives of this study as described in the District's Request for Proposal dated October 11, 1985 are as follows:

1. Establish through an analysis of cost and availability, potential sources of supply for the current and projected District water demand.
2. Based on requirements of the Colorado Department of Health and the Environmental Protection Agency, develop treated water quality goals.

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3. Select the most feasible treatment for organic contaminant removal with consideration of cost, constructability, and reliability in meeting treated water quality goals. The organic contaminant removal processes to be evaluated are: air stripping, granular activated carbon adsorption, and granular activated carbon adsorption used in combination with air stripping.
4. Determine the feasibility of blending contaminated water with other sources to meet treated water quality goals.
5. Recommend a softening alternative as an additional cost to organic contaminant removal.
6. Estimate the cost and implementation schedule for the selected treatment processes.

SCOPE OF WORK

Following a request for proposals, submittal of proposals by consultants, and interviews, the District selected James M. Montgomery, Consulting Engineers, Inc. (JMM) for the project. The contract, dated December 30, 1986, contained the scope of work outlined below:

1. Evaluate Treatment Alternatives
 - 1.1 Collect Data
 - 1.2 Screen Alternatives
 - 1.3 Hold Joint Technical Advisory Meeting (JTAC)
 - 1.4 Recommend Treatment
2. Evaluate Blending Alternatives
 - 2.1 Collect Data

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- 2.2 Analyze Blending
- 2.3 Document Analysis
- 3. Evaluate Softening Alternatives
 - 3.1 Evaluate Water Quality
 - 3.2 Review Treatment Alternatives
 - 3.3 Evaluate Alternatives
- 4. Evaluate Supply and Treatment Alternatives and Prepare Preliminary Report
 - 4.1 Evaluate Treatment and Supply Alternatives
 - 4.2 Prepare Draft Preliminary Report
 - 4.3 Prepare Preliminary Report
- 5. Estimate Cost and Schedule for Selected Alternatives
 - 5.1 Determine Preliminary Design Criteria
 - 5.2 Prepare Cost Estimate
 - 5.3 Prepare Implementation Schedule
 - 5.4 Document for District and JTAC Review
- 6. Prepare Final Report

JMM also assisted the District in an evaluation of temporary, emergency facilities to remove TCE from their 77th and 64th Street wells. This assistance was provided by JMM in conjunction with but not as part of the above scope of work. A discussion of this evaluation is therefore not included in this report.

CHAPTER 2

CHAPTER 2

EXISTING AND FUTURE POTENTIAL WATER SUPPLY

The District currently has limited entitlement to three sources of supply: deep well water from the Laramie-Fox Hills and Arapahoe Aquifers; shallow alluvial wells; and currently leased rights to Burlington Ditch water. These sources of supply and other future potential sources of supply are reviewed with regard to historical and supplemental use.

HISTORICAL DEMAND

The historical demand for the District was reviewed in the recent master plan (JMM, 1985). Present, year 2010 and ultimate demands are summarized from that report in Table 2-1. Maximum day demands are based on a historical peaking factor of 2.5. Based on demand projections, the present average day usage will double by the year 2010 and more than triple at ultimate build-out of the existing and future District area. The buildout of the existing area is based upon the probable relocation of Stapleton International Airport to an area northeast of the RMA and adjacent to the District's eastern boundary.

TABLE 2-1

SACWSD PROJECTED WATER DEMAND

Year	Average Day (MGD)	Maximum Day (MGD)
1986	4.1	10.2
2010	13.2	33
Ultimate	17.3	43

Existing and Future Potential Water Supply

SUPPLY

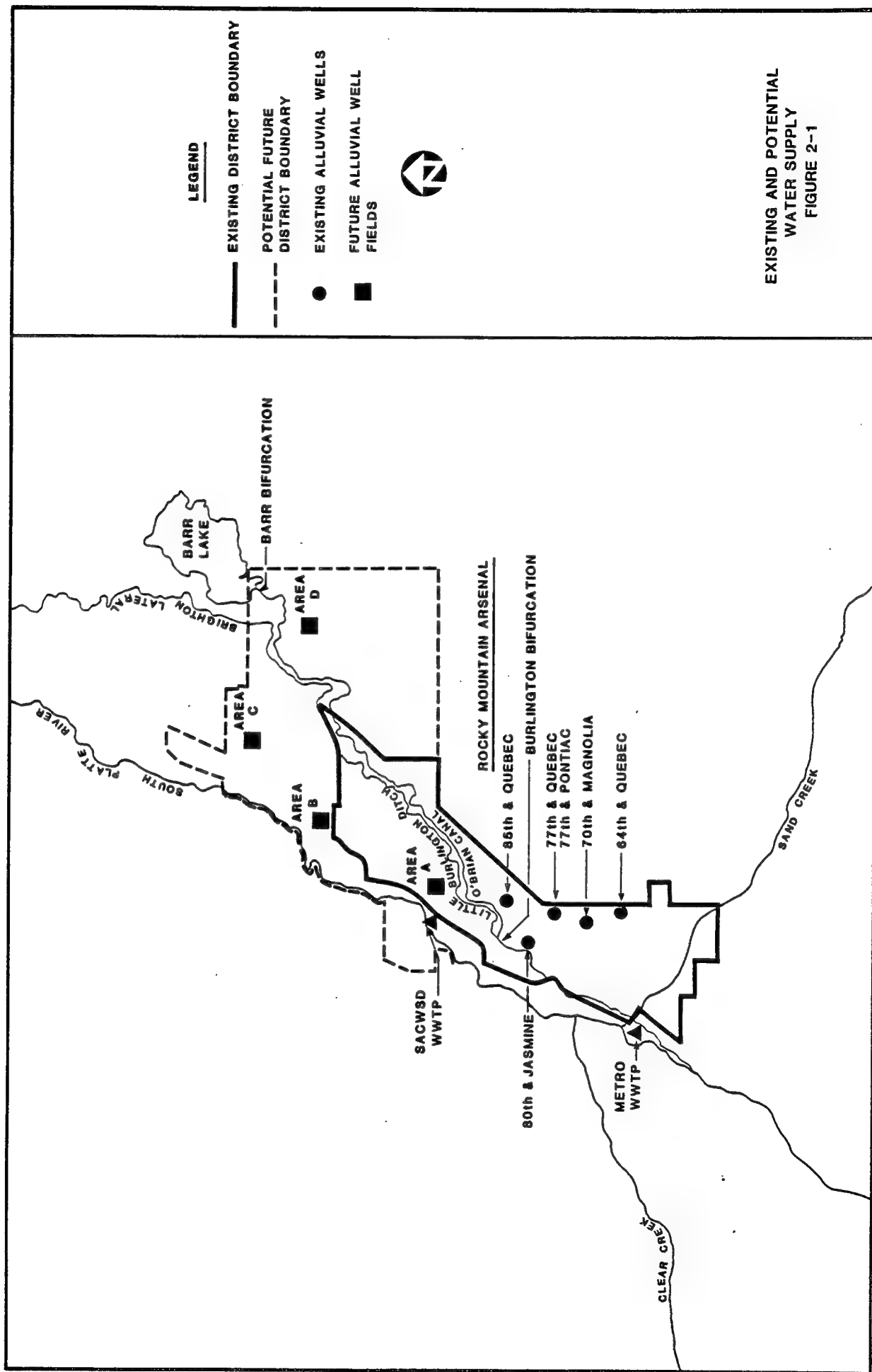
Figure 2-1 illustrates the existing and future potential sources of supply for the District. Deep wells, which are not shown on Figure 2-1, are located at a number of the alluvial well sites. Deep wells are also located at 56th and Niagara Street and Adams City pump stations.

Existing Supply

About 85 percent of the District's present day demand is met by eight of their nine shallow alluvial wells. Table 2-2 lists the existing shallow wells and their respective capacities. Seven of these wells have independent decreed flow rates with a total decreed capacity of approximately 12.5 mgd, excluding Well No. 7. The actual capacity, however, depends on seasonal variation of the formation yield. Presently, the average capacity of these wells is about 10 mgd. Well No. 18 is an alternate source of decreed flow for wells 2 and 3, and well 17 is similarly an alternate for well 5. Thus, wells 17 and 18 do not contribute to the total capacity of the existing facilities.

TABLE 2-2
EXISTING ALLUVIAL WELLS

SACWSD Well No.	Location	Decreed Flow Rate (gpm)	Remarks
2	77th & Pontiac	996	
3	77th & Pontiac	2,092	
5	77th & Quebec	3,492	
7	SACWSD WWTP	251	Used at the SACWSD WWTP
14	64th & Quebec	987	
15	80th & Kearney	310	
16	70th & Monaco	799	
17	77th & Quebec	3,492	Alternate point of diversion for Well No. 5
18	84th & Quebec	3,088	Alternate point of diversion for Well Nos. 2 and 3



EXISTING AND POTENTIAL
WATER SUPPLY
FIGURE 2-1

Existing and Future Potential Water Supply

The remaining 15 percent of the District's demand is supplied by eight deep wells which have a total decreed capacity of 2,315 acre-feet per year (2.1 mgd).

Prior to the recent discovery of organic contamination in the District's most productive alluvial wells, the present capacity was able to meet peak demand. Expansion of the District into the area northeast of Commerce City will require additional sources of supply. Potential sources of supply are reviewed below.

The District owns water rights to surface water in the Burlington-Wellington system. Through the existing Duggan, Burlington-Wellington rights, the District is entitled to an average flow of about 0.87 mgd. This flow would be limited to the historical diversion season of April through October. The District has utilized these rights by lease. Use of this surface water for replacement of stream depletions is planned.

Future Potential Supply

The District has investigated principally three other sources of water supply: new alluvial and deep wells in the future district area and existing district, purchase of additional of Burlington Ditch water rights; and participation in the Metropolitan Water Development Agency (MWDA) Agreement (Spronk, 1986). In 1983, the District requested an additional 25 proposed alluvial wells to be added to its augmentation plan. These wells would be located in the future District area to northeast of their present service area. Recently, HRS Water Consultants, Inc. has evaluated the location and cost of these additional well supplies.

A possible scenario is to provide, over the next 50 years, 21 new shallow wells located in Areas A, B, C and D as shown in Figure 2-1. Area A well field would provide the greatest capacity with a total of 16.5 mgd ultimately. Area B would have an estimated capacity of 1.72 mgd and C and D approximately 6.9 and 6.0 mgd, respectively. The implementation and staging of these additional wells would meet the required demand projections through the year 2035. In addition

Existing and Future Potential Water Supply

to these wells, a number of deep wells would be added to the system to supply the additional needed demand and to replace out-of-priority tributary well depletions. Additional surface water rights will need to be purchased and used to replace out-of-priority effects on the river.

The additional deep wells will be located primarily in the future District area. Approximately 6.8 mgd of additional capacity would be added to the system, providing a total deep well capacity of about 10.6 mgd. With the present decreed capacity of 12.5 mgd and the estimated future alluvial shallow well capacity of 21 mgd, this scenario would provide an ultimate groundwater supply of approximately 44 mgd. This would be sufficient to meet ultimate maximum day demand.

Purchase of Burlington Ditch Water Rights. The cost and availability of additional capacity from the Burlington Ditch water rights was evaluated in the Spronk study. Additional rights to this water could be obtained by the District through purchase of shares in the Burlington, Wellington and FRICO Companies. The total available capacities through these purchases would be approximately 4,300 acre-feet per year or about 3.86 mgd.

The useful capacity of these rights for peak flow may actually be greater than 3.86 mgd. The daily withdrawal rate could be extended to meet maximum day demand from the supply, however, this would depend on restrictions for instantaneous diversion flows and available storage capacity. It was suggested that in order to fully utilize this capacity, a treatment plant and pumping facilities would probably be located near Barr Lake.

Involvement in Metropolitan Water Development Agreement. The District would participate in this agreement through purchase of shares which are not presently available. Moreover, it was indicated that if any shares become available, present shareholders have first opportunity to purchase them. Also, several current shareholders have expressed an interest in acquiring additional shares of MWDA. Because of the uncertain availability of shares, this does not appear to be a viable alternative.

Existing and Future Potential Water Supply

Approximate Cost of Water Supplies

Table 2-3 shows the approximate supply costs of the existing water supply based on information provided by the District. The range in the cost of deep well water supply represents the difference in cost between the Arapahoe and Laramie-Fox Hills deep well waters. Historically, the alluvial water has been the least expensive source of supply for the District.

TABLE 2-3
SUMMARY OF EXISTING SACWSD WATER SUPPLY

Source	Decreed Capacity (mgd)	Actual Capacity* (mgd)	Approximate Cost (\$/Acre-Ft)
Alluvial Wells	12.5	10.1	10-20
Deep Wells	3.8	0.5	200-400
Burlington Ditch**	0.87	-	-

* Based on existing pumping and conveyance facilities

** Presently leased

Table 2-4 shows the approximate capacity and estimated supply and total costs for future potential sources of supply for the District. Capacities of Burlington Ditch and MWDA water are based on annual average flows. As previously indicated, these may be increased, depending on restrictions on instantaneous diversion and available storage. The estimated supply cost of the waters includes capital and operation and maintenance (O&M) costs for the shallow and deep water supplies. For the Burlington Ditch water, the supply cost represents the cost of purchasing additional shares.

Total estimated water costs include the approximate cost of treating and supplying the water. It was assumed that because of the superior quality of deep

Existing and Future Potential Water Supply

well water, treatment would not be necessary. The actual cost of deep well water may be slightly higher than indicated as a result of additional minor site work and yard piping and installation of the well facilities.

About \$150 to \$200 per acre-foot was added to the supply cost for alluvial water. These costs correspond to about 50 to 70 cents per 1000 gallons of treated water assuming that granular activated carbon or air stripping would be provided to meet future Federal and State water quality standards.

TABLE 2-4

FUTURE POTENTIAL SOURCES

Source	Potential Capacity (mgd)	Approximate Supply Cost (b) (\$/Acre-Ft)	Approximate Total Cost(c) (\$/Acre-Ft)
Alluvial Wells	31	100-200	250-350
Deep Wells	6.8	200-400	200-400
Burlington Ditch	3.8(a)	800-900	1,000-1,100
MWDA-P&CRSPPA	17.3	300-500	600-700

- (a) Annual average Burlington Ditch maximum day flow rates may be greater depending available storage and restrictions on maximum diversion flows.
- (b) Ground water supply costs include drilling and equipping the wells only. Surface water supplies include the cost of additional shares. Unit costs assume 30 year amortization at 8%.
- (c) Representative of cost to the consumer.

Existing and Future Potential Water Supply

An estimated \$200 to \$300 per acre-foot was added to the supply costs for Burlington Ditch and MWDA water for treatment and supply. This range of treatment costs is typical for capital facilities and operating costs for a conventional water treatment plant. Depending on the water treatment plant location and ultimately the water quality that would be treated, treatment costs may be higher for these two supplies.

This comparison of supply availability and approximate total treatment cost suggests that further development of shallow and deep wells is by far the most cost-effective. MWDA water appears to be the next most cost-effective source of supply, however, because of the unavailability of shares it is unlikely that the District will be able to participate in this Agreement. The Burlington Ditch water supply is considerably more expensive than the other sources. In addition, there is concern with regard to water quality of this supply, which, depending on intake location, may be susceptible to significant sewage discharge.

CHAPTER 3

CHAPTER 3

WATER QUALITY AND REGULATORY REQUIREMENTS

Historical water quality and regulatory requirements for treated water quality with regard to organic contaminants are reviewed. In addition, mineral quality of existing and future wells are summarized as a basis for cost estimates for lime and sodium ion exchange softening discussed in Chapter 6.

FEDERAL REGULATIONS

The Environmental Protection Agency's (EPA, 1985) recent proposed rules for drinking water contaminants revise primary standards and affect community water supplies. The following discusses the EPA proposed rulemaking, the rationale behind the EPA's actions, and the future course of the regulations. Following EPA promulgation of regulations, States with primacy must develop their own regulations that are at least as stringent as EPA's.

Action

On November 13, 1985, the EPA published in the Federal Register proposed maximum contaminant levels (MCLS) and final recommended MCL's (RMCL's) for eight volatile synthetic organic chemicals (VOCs). They also published RMCLs for 37 synthetic organic chemicals (SOCs) (plus two by-products), four microbiological contaminants, inorganics plus proposals for mandatory filtration of surface waters and disinfection of ground water. The proposed MCLs and final RMCLs for the VOCs are listed in Table 3-1 and the proposed RMCLs for the SOCs are listed in Table 3-2. A proposed RMCL of zero for tetrachloroethylene has been proposed, but the final RMCL and proposed MCL will be issued later.

Water Quality and Regulatory Requirements

TABLE 3-1
PROPOSED MCLs AND FINAL RMCLs FOR
VOLATILE ORGANIC COMPOUNDS

Compound	Proposed MCL (ug/l)	Final RMCL (ug/l)
Trichloroethylene	5	0
Carbon tetrachloride	5	0
Vinyl Chloride	1	0
1, 2-Dichloroethane	5	0
Benzene	5	0
1, 1-Dichloroethene	7	7
1, 1, 1-Trichloroethane	200	200
p-Dichlorobenzene	750	750

Water Quality and Regulatory Requirements

TABLE 3-2
PROPOSED RMCLs FOR SYNTHETIC ORGANIC CHEMICALS

Compound	Proposed RMCL (ug/l)
Acrylamide	0
Alachlor	0
Aldicarb, aldicarb sulfoxide, and aldicarb sulfone	9
Carbofuran	36
Chlordane	0
<u>cis</u> -1, 2-Dichloroethylene	70
DBCP	0
1, 2-Dichloropropane	6
o-Dichlorobenzene	620
2,4-D	70
EDB	0
Epichlorohydrin	0
Ethylbenzene	680
Heptachlor	0
Heptachlor epoxide	0
Lindane	0.2
Methoxychlor	340
Monochlorobenzene	60
PCBs	0
Pentachlorophenol	220
Styrene	140
Toluene	2,000
2,4,5-TP	52
Toxaphene	0
<u>trans</u> -1, 2-Dichloroethylene	70
Xylene	440

Water Quality and Regulatory Requirements

Rationale

The development of drinking water regulations follows a two-step standard-setting process. Initially, RMCLs are non-enforceable health goals set at a level where "no known or anticipated adverse effects on the health of persons occur and which allows an adequate margin of safety." Next, enforceable MCLs are set as close to the RMCL as feasible, based on factors such as treatment technology, cost, and availability of analytical methods.

Future Actions

Following the release of new data on the toxicology of tetrachloroethylene, the public comment period on its RMCL was reopened for 45 days (after November 13, 1985). When the RMCL for tetrachloroethylene is promulgated, the MCL will be proposed.

Written comments on the VOCs regulation were due by February 11, 1986. The final MCLs are scheduled for promulgation thereafter, likely in 6 to 12 months. Then the MCLs become effective 18 months after promulgation (February-August 1988, estimated).

STATE REGULATIONS

The State of Colorado is required to establish primary water quality standards which must be at least as strict as the EPA's. The responsibility to set and enforce standards belongs to the Colorado Department of Health (CDH). CDH's requirements for treated water quality are essentially the same as the EPA requirements. A number of organic contaminants such as Diisopropylmethylphosphonate (DIMP) are of concern with regard to health impact but which are unique to the RMA. Consequently, EPA guidelines for acceptable levels of some RMA-specific contaminants are not available. JMM and the District discussed with CDH the specific requirements for water quality and requisite treatment (CDH, 1986). Correspondence between JMM and CDH

Water Quality and Regulatory Requirements

on the treatment requirements of SACWSD water supply are contained in Appendix B. The following summarizes these requirements.

1. The treated water quality will meet promulgated State and Federal drinking water maximum contaminant levels (MCL's) in effect as of January 1986.
2. The water will meet the MCL's for volatile organic chemicals (VOC's) proposed by EPA in the November 13, 1985 Federal Register.
3. The District will attempt to meet the proposed RMCL's for synthetic organic chemicals (SOC's) and inorganic chemicals.
4. The District will provide treatment to reduce concentrations of Arsenal-unique compounds.
5. The District will meet all other MCL's for organic, inorganic, microbiological and radiological contaminants.

HISTORICAL WATER QUALITY

Considerable data on historical levels of organic contaminants in the District's existing ground water supply, and monitoring and private wells in the future district area have been collected. The existing wells generally have higher concentrations of the more volatile organics, principally trichloroethylene, while the future District area shows greater concentration of nonvolatile organics clearly associated with the RMA.

Existing Ground Water Supply

Table 3-3 summarizes the results of four sets of ground water analyses. The first was collected in June, 1983 and the last in December, 1985. Laboratory reports are included in Appendix C. In addition to these, a number of other

TABLE 3-3
AVERAGE AND MAXIMUM CONCENTRATIONS OF
ORGANIC CONTAMINANTS IN EXISTING WELLS*

	Trichloro- ethylene		Tetrachloro- ethylene		1,1,1 Trichloro- ethane		1,1 Dichloro- ethane		1,2 Dichloro- ethene		Methylene Chloride	
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
Alluvial Wells												
No.												
2	15	31	5.5	11	3.7	7	2.5	10	0.1	0.7	4	9
3	31	46	5	8	3.9	5	0.7	2	1.3	3.0	4	9
5	6	11	3.2	4	ND	ND	0.07	0.2	0.7	2.1	3	7
14	36	56.7	2.1	2.3	1.5	2.6	0.9	1.5	4.4	7.1	-	ND
15	2	4.0	1.5	2.8	0.9	1.7	1.8	3.0	0.5	1.6	2.5	5
16	10.1	15	6	8	4.0	5.0	1.4	3.1	1.7	3.0	-	ND
17	7	10	0.6	1.0	2.2	4.0	ND	ND	ND	ND	2	4
18	2.2	6	1.0	0.6	0.1	0.3	ND	ND	ND	ND	5	11
Deep Wells												
No.												
1	-	2.0	-	ND	-	ND	-	ND	-	ND	-	ND
4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
8	0.2	0.4	ND	ND	ND	ND	0.04	0.08	ND	ND	-	-
9	0.6	1.2	ND	ND	ND	ND	ND	ND	ND	ND	-	-
11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-
12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-

* ND indicates that the compound was not detected. Average concentrations are approximate and assume ND = 0

TABLE 3-3
CONCENTRATIONS OF
ORGANIC CONTAMINANTS IN EXISTING WELLS*
(continued)

	Dichlorobromo- Methane		Dibromochloro Methane		Bromoform		Benzene		Toluene		1,1, Dichloro- ethene		Chloroform	
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
Alluvial Wells														
No.														
2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1	0.5	ND	ND
3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3	0.9	ND	ND
5	ND	ND	ND	ND	5	14	ND	ND	ND	ND	0.1	0.5	0.07	0.2
14	ND	ND	ND	ND	ND	ND	0.2	0.6	0.04	0.08	0.3	1.0	ND	ND
15	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1	0.3	ND	ND
16	ND	ND	0.2	0.4	0.7	2.2	ND	ND	ND	ND	1.7	4.0	0.1	0.3
17	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.08	0.3	ND	ND
18	ND	ND	0.3	0.7	1.8	5.4	ND	ND	0.7	2.0	ND	ND	ND	ND
Deep Wells														
No.														
1	-	ND	-	ND	-	ND	-	ND	-	-	-	ND	-	ND
4	-	ND	-	ND	-	ND	ND	ND	-	ND	ND	ND	-	-
8	-	ND	-	ND	-	0.6	ND	ND	0.04	0.08	ND	ND	-	-
9	-	ND	-	ND	-	0.4	ND	ND	-	ND	ND	ND	-	-
11	-	ND	-	ND	-	ND	ND	ND	-	ND	ND	ND	-	-
12	-	ND	-	ND	-	ND	ND	ND	-	ND	ND	ND	-	-

* ND indicates that the compound was not detected. Average concentrations are approximate and assume ND = 0

Water Quality and Regulatory Requirements

samples sets have been collected by various agencies. The results generally agree with those presented here. One or more of the reports excluded certain sample locations or specific organics. Thus, average values were not appropriate. In addition, approximate average values were assumed to be the average of reported concentrations and zero where concentrations were below detection limits. This assumption yields average concentrations which are lower than the true average. However, the error in making this assumption is not significant for the purpose of this study, particularly for those compounds such as trichloroethylene (TCE) which have detection levels well below the MCL and, for the wells of concern, which have concentrations significantly greater than the MCL.

The approximate average concentrations shown in Table 3.3 are intended to indicate the frequency of the reported maximum concentrations. An approximate average concentration close to the maximum concentration suggests that most of the samples analyzed were consistently near the maximum concentration.

The District's alluvial wells were typically sampled in every set, while the deep wells were monitored less frequently. As indicated in Table 3-3, TCE is the principal contaminant of concern. Maximum concentrations exceeding the proposed MCL were observed in six of the District's tributary alluvial wells. The Pontiac Street wells Nos. 2 and 3 concentrations have been consistently high with average concentrations of 15 and 31 ug/l, respectively. Well No. 14 has also consistently produced high levels of TCE. Tetrachloroethylene (PCE) and 1,1,1-trichloroethane (TCA) were also frequently observed in the alluvial wells, however at considerably lower levels than TCE.

Some of the trihalomethanes (THM), notably chloroform, dibromochloromethane and bromoform, were detected in several wells. The concentrations are assumed to be related to chlorination practices. In every case the concentrations are well below the present MCL of a total of 100 ug/l for THMs.

Water Quality and Regulatory Requirements

In a few samples, trace amounts of TCE and dichloroethane were detected in the District's deep wells. The levels were far below current or proposed MCL's for these compounds. It has been suggested that the contaminants are the result of local intermixing at the well site of the alluvial and the deep formation water.

Pesticides and semivolatile organics were monitored in alluvial and deep wells in January 1985 and February 1986. A list of the organics analyzed for and the results are included in Appendix C.

Trace levels of tentatively identified 1,1 dichloroethane, di-n-butylphthalate and n-nitrosophenylamine were detected in duplicate samples of Well No. 13, 56th and Niagara. Also trace quantities of two phthalates were detected in single samples from Wells 4 and 9. Most of the other organics detected were predominantly chlorinated volatile organics in the alluvial wells. Volatile results are included in Table 3-3. Other synthetic organics including those unique to the RMA, such as DIMP, were not detected.

Future Potential District Wells

The level of organic contamination and the ground water supply in the future District area has been the subject of investigations by Rocky Mountain Arsenal beginning in 1975. Results of ground water monitoring between December of 1984 and January of 1985 are given in the RMA Off-post Assessment Ground Water Quality Report (ESE, 1985). Through an agreement with the EPA and CDH, the RMA initiated an off-post contamination assessment study, the objectives of which were to generate a representative data base for use in evaluating ground water quality and to identify areas of significant public exposure related to consumptive use of contaminated ground water.

The boundaries of the study are described as a line extending east to west along east 80th Avenue from the western boundary of RMA to South Platte River. The western boundary is the South Platte River and the northeast boundary is Second Creek from the northeast corner of RMA to its confluence with the South Platte

Water Quality and Regulatory Requirements

River. The study area was based on the area of impact of the northwest migration of contaminants from the Arsenal.

Table 3-4 lists organic contaminants that have been of principal concern in the off-post study. Organic contaminants were detected in 53 of the 117 alluvial and deep wells monitored in the study. Table 3-5 summarizes the number of positive results of the wells sampled for organics. Contamination by DIMP, a by-product of nerve gas manufacturing, appeared to be widespread with levels detected in 46 of the 53 wells showing contamination. Fifty-one of the wells in which the organics were measured were alluvial supplies. Two bedrock wells from the Arapahoe formation contained the detectable concentrations of DIMP. It was suggested in the report that since DIMP was not found in the shallower Denver formation, the contamination of the deep Arapahoe wells was most likely the result of poor well construction or corrosion of the well casing. Dimethylmethylphosphonate (DMMP) was not detected in any of the ground water supplies. The CDH, however, has pointed out that the detection limits are quite high for this compound and that there is potential for levels below current detection limits in the study area. Figure 3-1 shows the areas of highest contamination in relation to the District's proposed future well field sites at areas A, B, C and D. This figure further illustrates that the greatest contamination is in the northwest corner of the RMA, approximately two miles from the proposed site for Area B. Figure 3-1 indicates that DIMP is the most widespread contaminant. Dibromochloropropane was detected in 3 wells.

This data also suggests that of the future well field areas proposed by the District, Area B may be subject to the greatest potential for additional contamination due to the apparent areas of greatest contamination and the direction of ground water flow.

Water Quality and Regulatory Requirements

TABLE 3-4

**ORGANIC CONTAMINANTS SURVEYED IN THE RMA OFF-POST
ASSESSMENT GROUND WATER QUALITY REPORT (ESE, 1985)**

Volatile Organics

Chlorinated Pesticides (aldrin, dieldrin, endrin, isodrin)

Dibromochloropropane (DBCP)

Diisopropylmethylphosphonate (DIMP)

Dimethylmethylphosphonate (DMMP)

Dicyclopentadiene (DCPD)

1,4-Dithiane/1,4-Oxathiane

p-Chlorophenylethyl Sulfone (PCPMSO₂)/Sulfoxide (PCPMSO)/

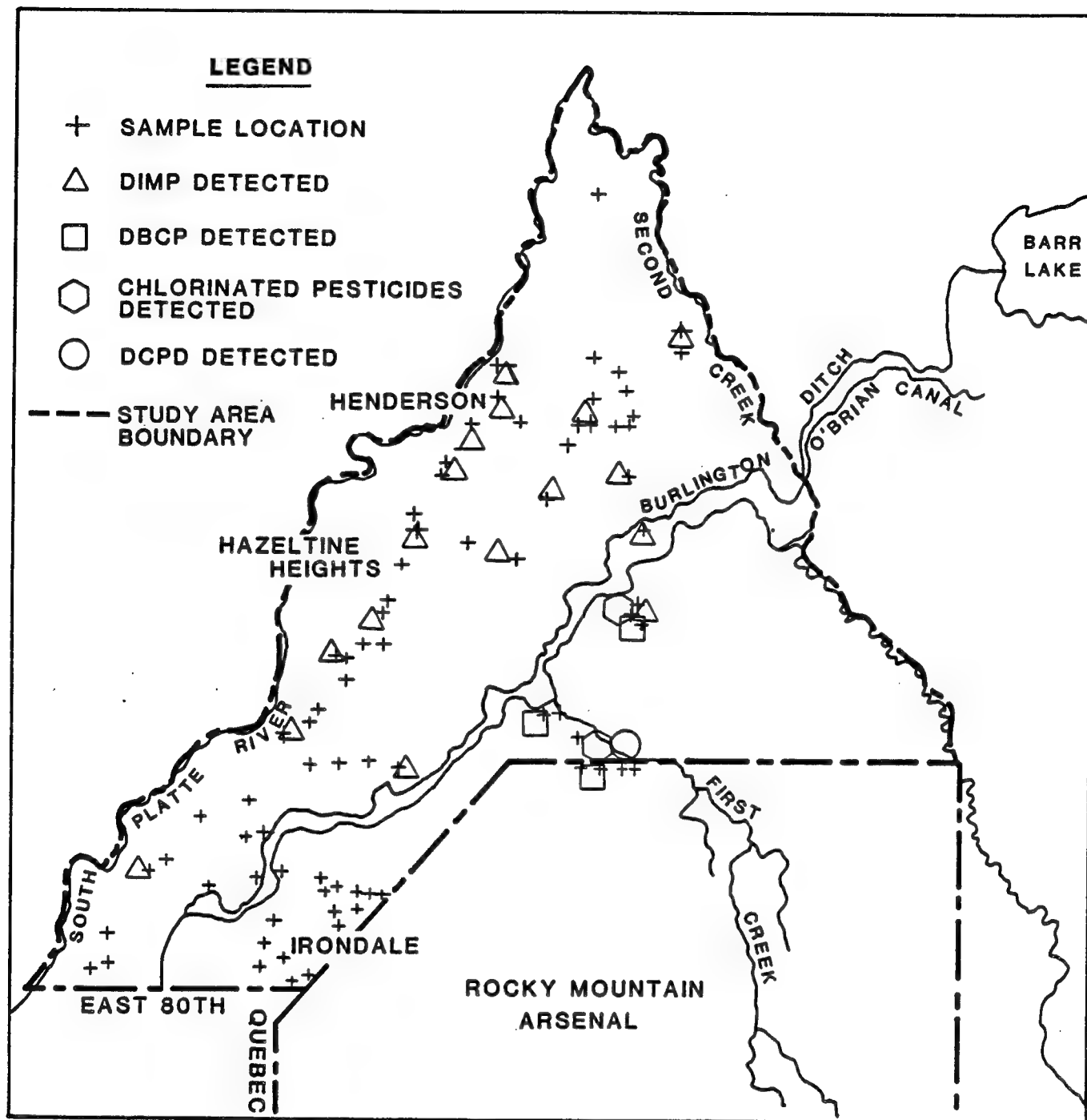
Sulfide (PCPMS)

Water Quality and Regulatory Requirements

TABLE 3-5

**SUMMARY OF OFF-POST ASSESSMENT RESULTS
FOR DECEMBER 1985 THROUGH JANUARY 1985 (ESE. 1985)**

Compounds Detected	Detection Limit (ug/l)	Frequency Detected
Diisopropylmethylphosphonate (DIMP)	1.9	46
Aldrin	0.13	1
Endrin	0.07	3
Dieldrin	0.16	3
Isodrin	0.18	1
Dibromochloropropane (DBCP)	0.11	3
Dicyclopentadiene (DCPD)	24	3
Chloroform	1.4	9
t-1,2-Dichloroethene	1.2	1
Trichloroethylene	1.1	8
Tetrachloroethane	1.3	7
Toluene	1.2	2



LOCATION OF SAMPLING POINTS AND
DETECTED ORGANIC CONTAMINANTS
(FROM THE RMA OFF-POST ASSESSMENT
GROUNDWATER QUALITY REPORT
DECEMBER 1984 TO JANUARY 1985)

FIGURE 3-1

Water Quality and Regulatory Requirements

Other Considerations

Historical mineral quality of existing and future water supplies were evaluated to establish a basis for softening cost estimates. Table 3-6 summarizes data from a previous study (SGI, 1982) and from more recent water quality analyses for the future District area (Appendix C). Levels of hardness range from 300 to 500 mg/l as calcium carbonate. Approximately 80 to 100 mg/l of hardness is due to magnesium. Alkalinities range from 100 to 200 mg/l. Noncarbonate hardness is about 150 to 300 mg/l.

Arapahoe and Laramie-Fox Hills formation waters generally have low hardness with values ranging from 50 to 100 mg/l.

TABLE 3-6
SUMMARY OF GROUND WATER MINERAL QUALITY

Well	Hardness (as CaCO ₃)	Magnesium (as CaCO ₃)	Total Alkalinity (as CaCO ₃)	pH (Units)	TDS (mg/l)
Existing					
Alluvial(a)					
2 & 3 (b)	440	50	260	7.8	850
5 & 7	470	120	280	7.8	950
14	470	70	250	-	870
16	350	-	260	7.3	890
Future					
Alluvial(d)					
A	270	70	-	7.6	600
B	450-500	100-150	250-475	7.2-8.0	800-1300
C	400-500	100-160	300-350	7.2-7.3	800-1300
D	500-800	40-180	200-350	7.4-7.5	900-1600
Deep Wells(c)	10-30	0.5-10	150-550	8.0-8.8	200-800

(a) From Sellards and Griggs, 1982

(b) Average of two reported values

(c) From HRS, January 1986

(d) From Sellards and Griggs, 1982

CHAPTER 4

CHAPTER 4

EVALUATION OF BLENDING TO MEET TREATMENT GOALS

The feasibility of blending different sources of water to meet treated water quality requirements is evaluated in this Chapter. Historical water quality reviewed in Chapter 3 indicated that the principal contaminants are trichloroethylene found predominantly in the existing alluvial wells and DIMP found in the future potential District alluvial wells.

Blending contaminated water with uncontaminated water is the basis of this evaluation. Partial treatment was not considered. Also, facilities required to blend and associated costs were not considered. Depending on the requirements of the CDH and the uniformity of the blending within the distribution system, capital facilities may be required to blend prior to distribution to consumers. Average blend concentrations independent of the actual method of blending were assumed.

SOURCES FOR BLENDING

The potential sources of supply were reviewed in Chapter 2. All existing and future potential sources with the exception of the deep formation water supplies will require some form of treatment either for turbidity, microbiological removal or organic contaminant removal. The cost of acquiring rights for and treating available surface water is prohibitive. Treated or untreated surface water was not considered to be a viable supply for blending.

The sources available for blending with contaminated ground water are limited to existing and future nontributary water from the Arapahoe and Laramie-Fox Hills formations. As indicated in the alternative water supply study (Spronk, 1986), the District currently utilizes approximately 600 acre-feet per year of deep well water. The District has developed preliminary estimates of capacities

Evaluation of Blending to Meet Treatment Goals

of deep well water for the future District area. The proposed future deep wells would provide about 6.8 mgd of additional capacity which could be utilized for blending.

BLENDING FOR THE EXISTING GROUND WATER SUPPLY

Table 4-1 summarizes estimates of expected TCE concentrations for various blending scenarios based on the possible combinations of Wells 2, 3, 5, 17 and 18 usage, and assumed maximum and average TCE concentrations. The average blended concentrations were developed assuming in one scenario that the decreed flow from Well 18 would be utilized as an alternative to the Quebec Street Wells, Nos. 2 and 3. For another scenario, blended concentrations were developed assuming Wells 2 and 3 would be used and Well 18 would not. These two scenarios for well usage would cover the expected range of concentrations as affected by well use.

Also, for each well use scenario, average blend concentrations were developed for two different flows of deep well water. The lower value of 375 gpm is representative of the District's present usage and the 560 gpm flow represents the ultimate capacity that may be available to the District for the existing supply.

The average concentrations were calculated by flow-weighted, maximum, observed concentrations and average observed concentrations for each well from Table 3-3. The Pontiac Street wells have the highest average and maximum concentrations. Therefore, their use in place of Well 18, results in a significant increase in the blended TCE concentrations. An average of approximately 16 ug/l of TCE would be expected, utilizing the Pontiac Street Wells in lieu of Well 18.

Evaluation of Blending to Meet Treatment Goals

TABLE 4-1

ESTIMATED AVERAGE BLEND TCE CONCENTRATIONS FOR THE EXISTING GROUND WATER SUPPLY

Well Use	Based on the Maximum* Concentration Observed	Based on the Average* Concentration Observed
Well 18 on, Well 2 off, Well 3 off		
375 gpm from deep wells	12.2	7.9
575 gpm from deep wells	11.9	7.7
Well 2 on, Well 3 on, Well 18 off		
375 gpm from deep wells	26.0	16.0
575 gpm from deep wells	25.0	15.7

*Maximum and average TCE concentrations from Table 3-3

The lowest possible concentration using the entire well capacity would produce approximately 7.5 ug/l of TCE. Based on these estimates, blending to meet the proposed MCL of 5 ug/l does not appear to be a viable alternative for the existing water supply.

BLENDING IN THE FUTURE DISTRICT AREA

The potential for blending to achieve treatment levels for the future potential alluvial water supply depends largely on the concentrations of DIMP that would be expected once the well facilities are in operation. Presently, there is relatively little historical water quality data for the exact locations of the proposed future well sites for Areas A, B, C and D. The data that are available from the off-post study (ESE, 1985) indicate that DIMP is ubiquitous in the

Evaluation of Blending to Meet Treatment Goals

future District area with apparent highest concentrations potentially in Area B. It was assumed that for the purpose of cost estimates presented in Chapter 6, the DIMP concentrations in Area B would be between 300 and 500 ug/l. Concentrations of DIMP to the west of Area B have been measured at about 900 ug/l. Area C appears to have the next highest concentration, in the approximate range of 5 to 10 ug/l.

DIMP has been detected within a one to two mile radius of Area A. In addition, there appears to be TCE contamination of alluvial water in the vicinity of Area A, however concentrations are generally less than observed in the existing District area.

For this analysis, it was assumed that the DIMP concentrations in Area A are insignificant. In Areas C and D, a DIMP concentration of 10 ug/l was assumed. In Area B, a concentration of 350 ug/l was assumed. Table 4-2 summarizes the results of flow weighted concentrations expected by blending these various sources of water. A system-wide concentration of DIMP from blending all four future well fields would produce approximately 20 ug/l largely due to the assumed high value of DIMP in Area B. Assuming the Area B wells are not utilized, DIMP levels would be approximately 4 ug/l.

TABLE 4-2

ESTIMATED AVERAGE DIMP CONCENTRATIONS FOR BLENDING OF FUTURE GROUND WATER SUPPLIES

Alluvial Well Supply	Average DIMP (ug/l)
A, C & D	4
A, B, C & D	20

Evaluation of Blending to Meet Treatment Goals

Because of the lack of water quality data in the immediate vicinity of proposed well sites for the future potential areas, a conclusive analysis of the feasibility of blending these supplies cannot be made. However, based on the concentrations in the general vicinity of these well fields, it appears that DIMP cannot be reduced to less than its detection limits by blending with the proposed capacity of deep well water.

CHAPTER 5

CHAPTER 5

PRELIMINARY SCREENING AND EVALUATION OF ALTERNATIVES FOR ORGANIC CONTAMINANT REMOVAL

This chapter reviews alternatives for treating contaminated wells to meet EPA proposed MCLs and State requirements. Six alternatives were screened with regard to cost and feasibility. Of these, three alternatives were evaluated in greater detail.

PRELIMINARY SCREENING

Table 5-1 lists the six alternatives screened for organic contaminant removal. The range of costs are representative of those anticipated for the District's ground water supply. The costs were estimated from cost curves (EPA, 1979; Adams, 1985), actual construction costs for similar facilities, and well development costs provided by the District. The alternatives are briefly reviewed below.

No Treatment

This alternative represents no action to remove or reduce the organic contaminants in existing and future wells. Based on the TCE concentrations indicated in Table 3-3, District customers would be exposed to average concentrations ranging from 5 to 30 ug/l. The actual exposure level would depend on the location of the customer's service connection in relation to the well supply. Since these concentrations exceed the proposed Federal and State MCL, "no treatment" is not considered to be an acceptable alternative for existing alluvial supplies.

Evaluation of Alternatives for Organic Contaminant Removal

TABLE 5-1
ALTERNATIVES FOR REDUCTION OF ORGANICS IN EXISTING
AND FUTURE DISTRICT ALLUVIAL GROUND WATER SUPPLIES

Treatment Alternative	Cost \$/1000 Gal	Effectiveness	Reliability	Environmental Impact	Aesthetic Considerations	Constructability
No Treatment	0	No removal	NA	None	NA	NA
Withdrawal from Selected Strata (non-tributary Aquifer)	2-6		Inadequate water supply. Reliable in ability to meet treatment goal.	Depletion of deep groundwater	NA	Additional well installation
Air Stripping	15-70	>95% removal for volatile organics. Not effective for non-volatile organics.	Reliable. Simple features and operation.	Organics discharged to atmosphere. Steam/mist is visible and may ice nearby roads. Can be designed for noise reduction.	Normally, visible above ground facilities but can be treated architecturally.	Relatively little space required. Easily incorporated into existing facilities.
Air Stripping with Air Pollution Control (APC)	30-100	>95% removal for volatile organics. Not effective for non-volatile organics.	Air stripping equip. is reliable. Air pollution control equipment is more complex and requires greater maintenance.	With air phase-GAC used for air pollution control concentrated organics would be generated. Alternatively dispose of spent GAC.	Same considerations as air stripping.	APC equipment normally turnkey. Requires 1.5 to 2 times space requirement of air stripping. APC equipment should be housed.
Granular Activated Carbon Adsorption	50-75	>95% removal of volatile and non-volatile organics.	Reliable. Can be designed for pressurized, in-line treatment. Must be monitored to prevent breakthrough.	Spent GAC can be regenerated at a central location, otherwise must be disposed of offsite.	Facilities should be acceptable to nearby residents.	Easily installed, shop fabricated equipment.
Granular Activated Carbon preceded by air stripping	60-110		Reliable. Effective removal of volatile and nonvolatile	Spent carbon would be regenerated on or off site. Organics are discharged to the atmosphere unless air pollution control is provided	Same considerations as air stripping and GAC	Same considerations as air stripping and GAC.

The CDH has indicated that the District would be required to provide treatment for wells contaminated by organics originating from the RMA. Thus, any of these organics, notably DIMP, detected in the ground water would require treatment of the supply. The feasibility of no treatment for potential future alluvial wells to the northwest of the RMA will ultimately depend on the actual water quality once the wells are in operation. The historical data reviewed in Chapter 3 suggest that the occurrence of DIMP in future wells is likely. Based on the data presently available, no treatment does not appear to be feasible for future potential District alluvial wells.

Withdrawal From Selected Strata

This alternative assumes that the organic contaminants would be avoided by maximum use of the District's uncontaminated deep well water supply. As indicated in Chapter 3, this water supply is generally free of organic contaminants, with the exception of trace amounts detected in a few samples. The District is currently meeting 15 percent of its water demand by use of the deep well water. As previously noted, the District's use of deep well water is limited by decree. The decreed yield of the deep wells is considerably less than the shallow wells. Even at the District's maximum decreed flow rate for deep well water, only a fraction of the existing and future District demand could be met. Because of the lack of adequate supply, this alternative is not considered feasible for the District.

Air Stripping

Of the viable alternatives for treatment, air stripping is the least expensive. Air stripping facilities can be designed for removal efficiencies of 99 percent or greater. This process, however, is limited to relatively volatile organics like TCE. This process is not suitable for less volatile organics such as DIMP and many of the halogenated pesticides. Should these less volatile organics appear in the contaminated groundwater in the future, significant removals could not be cost effectively achieved by air stripping. In this regard, air stripping is not

Evaluation of Alternatives for Organic Contaminant Removal

considered to be as reliable as granular activated carbon, since there is potential for migration of nonvolatile organic contaminants to existing wells.

Air stripping facilities are operationally simple and easy to maintain. There is potential for process failure from excessive mineral scaling; however, this can be avoided by addition of antiscalants to the tower influent.

Air stripping facilities would be highly visible to the surrounding residential area. The height of the facility depends on the percent removal required. For example, an air stripping tower designed to achieve 95 percent removal would have a total height of approximately 30 feet. In the areas subject to low air temperatures and moderate ground water temperatures, air stripping facilities may produce visible fog or mist plumes adding to the visibility. With proper mist elimination systems, icing of roads by mist can be controlled. Generally, blowers required for removal of TCE are relatively small and do not require measures for noise reduction. However, air stripping of less volatile organics such as DIMP or DBCP requires much higher air to water ratios. Consequently, the blowers may be quite large with greater potential for noise. The facility can be designed with noise control features to effectively eliminate the problem. Finally, air strippers in some locations have not been well received by the public, even though estimated health risks are small, since the contaminants are transferred from the water to the air.

Air Stripping with Air Pollution Control

According to the CDH, facilities emitting organics may be required to have emissions control equipment, depending on the cost of the best available technology (BAT) for the equipment. If the cost of the BAT is greater than \$2,000 per ton removed from the emitted air then emission control may not be required. Based on the estimated discharge rates for the most contaminated District wells, the cost of BAT for this application would be substantially greater than \$2,000/ton.

Evaluation of Alternatives for Organic Contaminant Removal

However, the District would not be safe in assuming that the CDH will allow air stripping without air pollution control. Because of citizen's concerns and the possibility of more stringent federal emission standards in the future, it is increasingly more difficult to operate without air pollution control equipment. Furthermore, elimination of organic air emissions would be more acceptable than air stripping for residences exposed to higher TCE concentrations in the air.

The cost shown in Table 5-1 for this alternative assumes that the air stream from the air stripping tower would be treated by GAC adsorption with either onsite steam regeneration or GAC replacement. A large portion of the total cost is due to removal of mist and heating of the emitted air from the air stripper prior to the air pollution control equipment. Heating of the air is needed to reduce the relative humidity of the air stream to avoid condensation of water in the GAC system.

The air pollution control equipment can be complex, depending on the type of equipment selected. A system involving carbon adsorption vessels without onsite regeneration would be relatively simple. Once exhausted, the carbon would be removed and replaced with fresh carbon. Offsite regeneration facilities could be utilized for regeneration of carbon or a service contract with an outside firm to replace spent carbon could be initiated.

A system with onsite carbon regeneration would be considerably more complex. Such a system would include, in addition to the carbon absorption vessels, a steam boiler and associated makeup water treatment, a condenser and possibly equipment to separate condensed steam from the organic contaminants. Air pollution control equipment with onsite steam regeneration can be provided as a packaged system. Such equipment has been used extensively in industry for solvent recovery applications.

Granular Activated Carbon Adsorption

GAC adsorption can be designed to achieve removals equivalent to air stripping

and additionally remove a broad spectrum of organic compounds. In general, removals of greater than 90 percent can be provided for the organics observed in the District's well supply.

This alternative is considered to be more flexible than air stripping in that both volatile and nonvolatile organics can be removed. To ensure reliability, however, effluent samples must be collected on a routine basis so that premature breakthrough of the compounds does not occur. More effective use of the carbon and greater assurance of preventing breakthrough can be provided by utilizing two canisters in series as an adsorber system.

A principal cost associated with GAC adsorption is replacement or regeneration of spent carbon. This can be handled either through a service agreement with a company having facilities for regeneration or disposal at a landfill, or regeneration at a centralized facility operated by the District.

Granular Activated Carbon Preceded by Air Stripping

This process scheme is typically considered in applications where both volatile and nonvolatile organics are present. It is cost-effective when the concentrations of volatile contaminants are high and when such compounds are first to breakthrough the GAC effluent. By inexpensively removing most of the volatiles in the air stripping process, the GAC treated water volume between regenerations is increased. The cost-effectiveness of this process is a function of a cost trade-off between the capital cost of the air stripping equipment versus the cost of GAC regeneration.

This alternative is not considered to be feasible for treatment of the District's wells since the concentrations of volatile organics are not high enough to justify the capital cost of an air stripper in addition to the GAC system. This alternative would be subject to the same concerns as air strippers with regard to air pollution control as previously discussed.

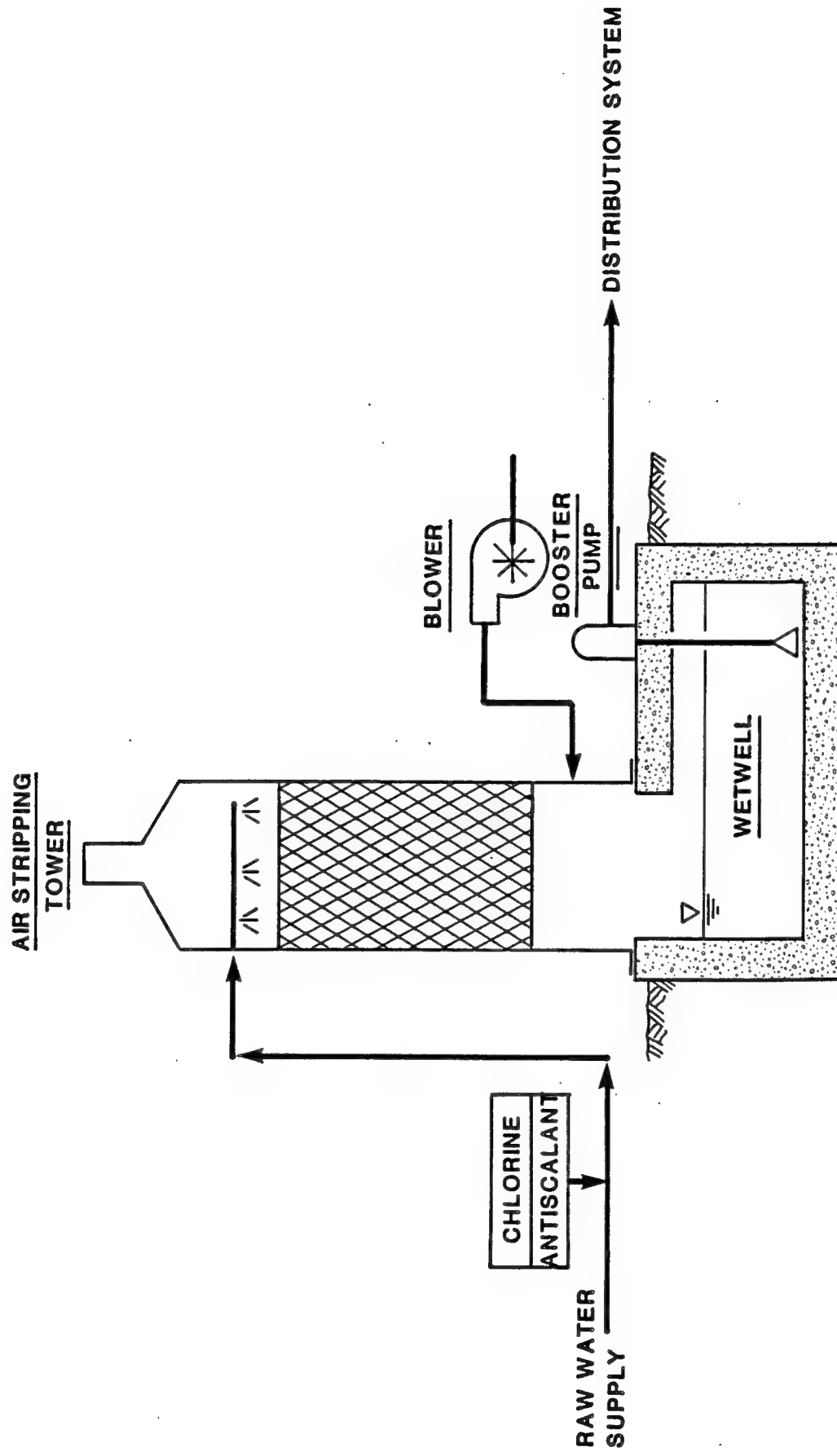
FEASIBLE ALTERNATIVES

Based on the preliminary screening of six alternatives for organic removal, it appears that the most viable are air stripping, air stripping with air pollution control and granular activated carbon adsorption. The other alternatives do not accomplish water quality or quantity objectives or are more costly. Figures 5-1, 5-2 and 5-3 illustrate the salient features of these processes.

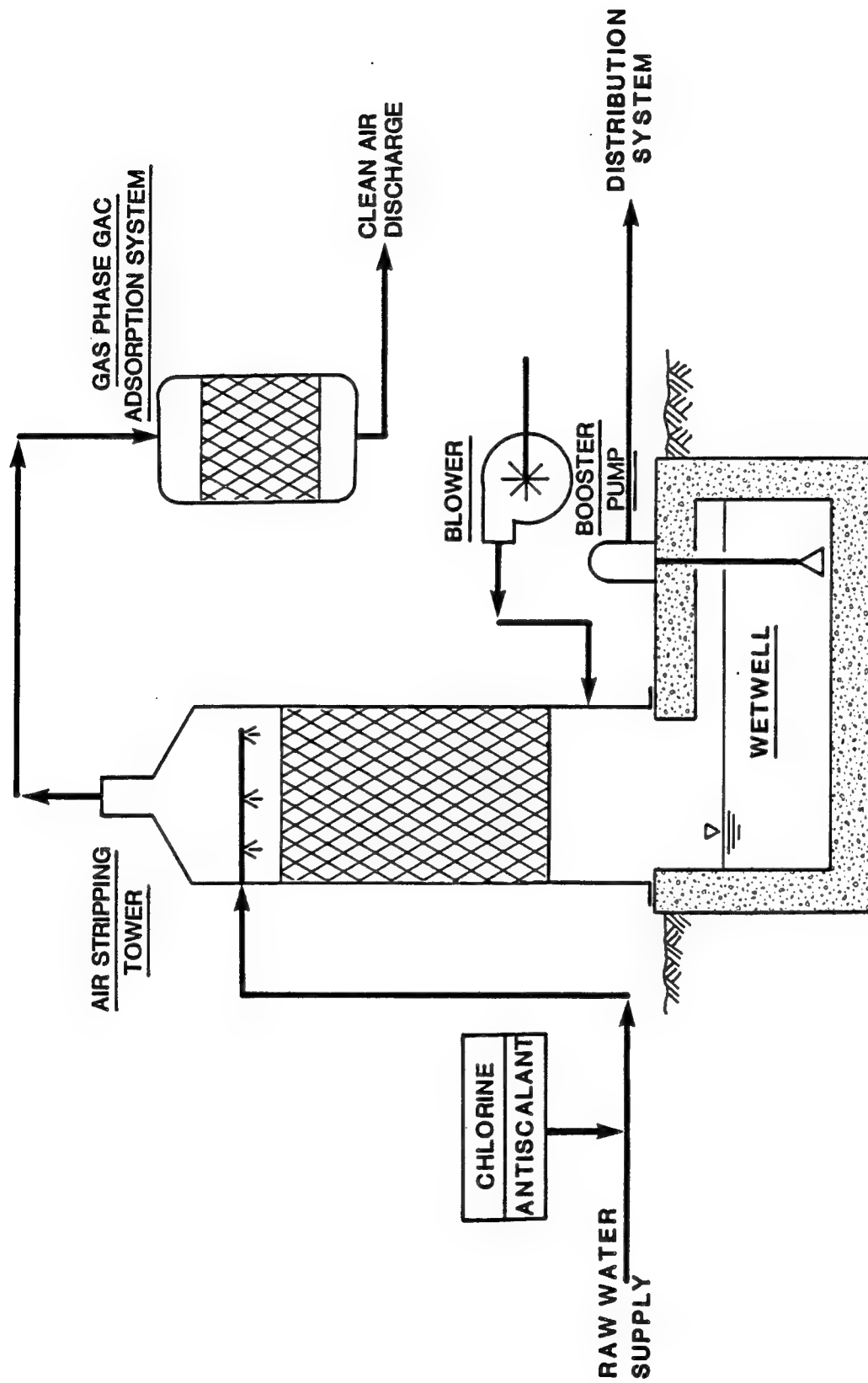
Detailed costs for air stripping, air stripping with air pollution control and granular activated carbon adsorption were developed for centralized and decentralized facilities for each alternative. Table 5-2 lists the assumptions used for the cost estimates. These estimates are order of magnitude estimates, based on available cost data (EPA, 1979; Adams, 1985). The estimated accuracy is expected to be within a range 20 percent lower or 30 percent higher than the actual cost. Pipeline costs were developed from JMM's Cost Estimating Manual (JMM, 1982).

Decentralized facilities assume that a separate treatment facility would be provided at each of the individual well sites in the existing District area for alluvial ground water supplies, with the exception of the 77th and Pontiac/Quebec Street wells. These facilities are sufficiently close to assume that a single plant would be provided. In addition, it was assumed that single facilities would be provided to serve Areas A, B, C, and D independently, although actual wells in these areas may be physically separated.

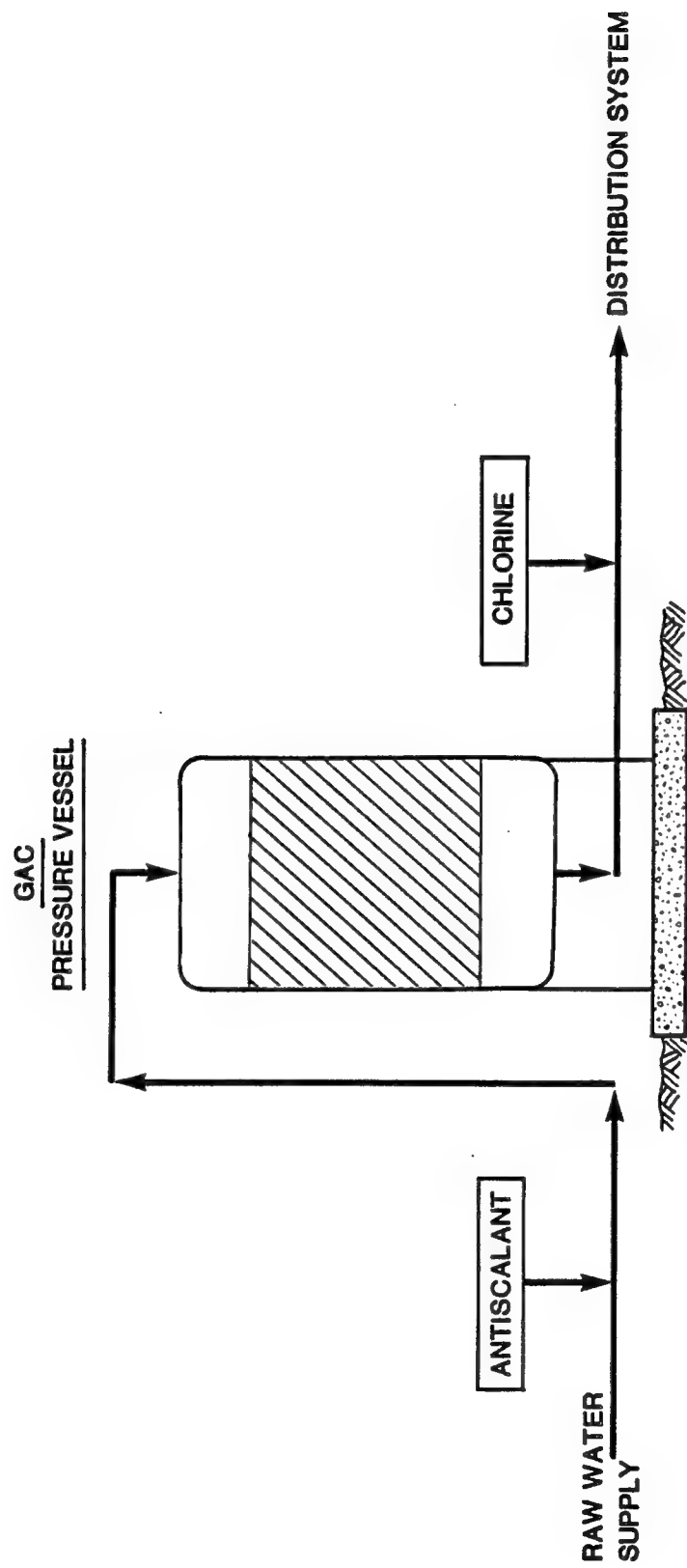
For centralization, it was assumed that four major treatment facilities would be provided as shown in Figure 5-4. One facility could serve all alluvial supplies in existing District area, a second would serve the wells in Area A, a third would serve the wells in Areas B and C and the fourth would serve area D.



AIR STRIPPING
FIGURE 5-1



AIR STRIPPING
WITH AIR POLLUTION CONTROL
FIGURE 5-2



LIQUID PHASE GRANULAR ACTIVATED CARBON
ADSORPTION

FIGURE 5-3

TABLE 5-2
ASSUMPTIONS FOR COST ESTIMATES

General

Denver ENR	=	3500
Interest Rate	=	8%
Amortization Period	=	30 yrs.
Max. Day/Avg. Day	=	2.5
Power Cost	=	\$0.048/Kw-hr
Labor (overhead included)	=	\$15/hr
Contractor Overhead and Profit	=	15%
Interest During Construction	=	5%
Engineering	=	10 - 20%
Contingency	=	10%

GAC

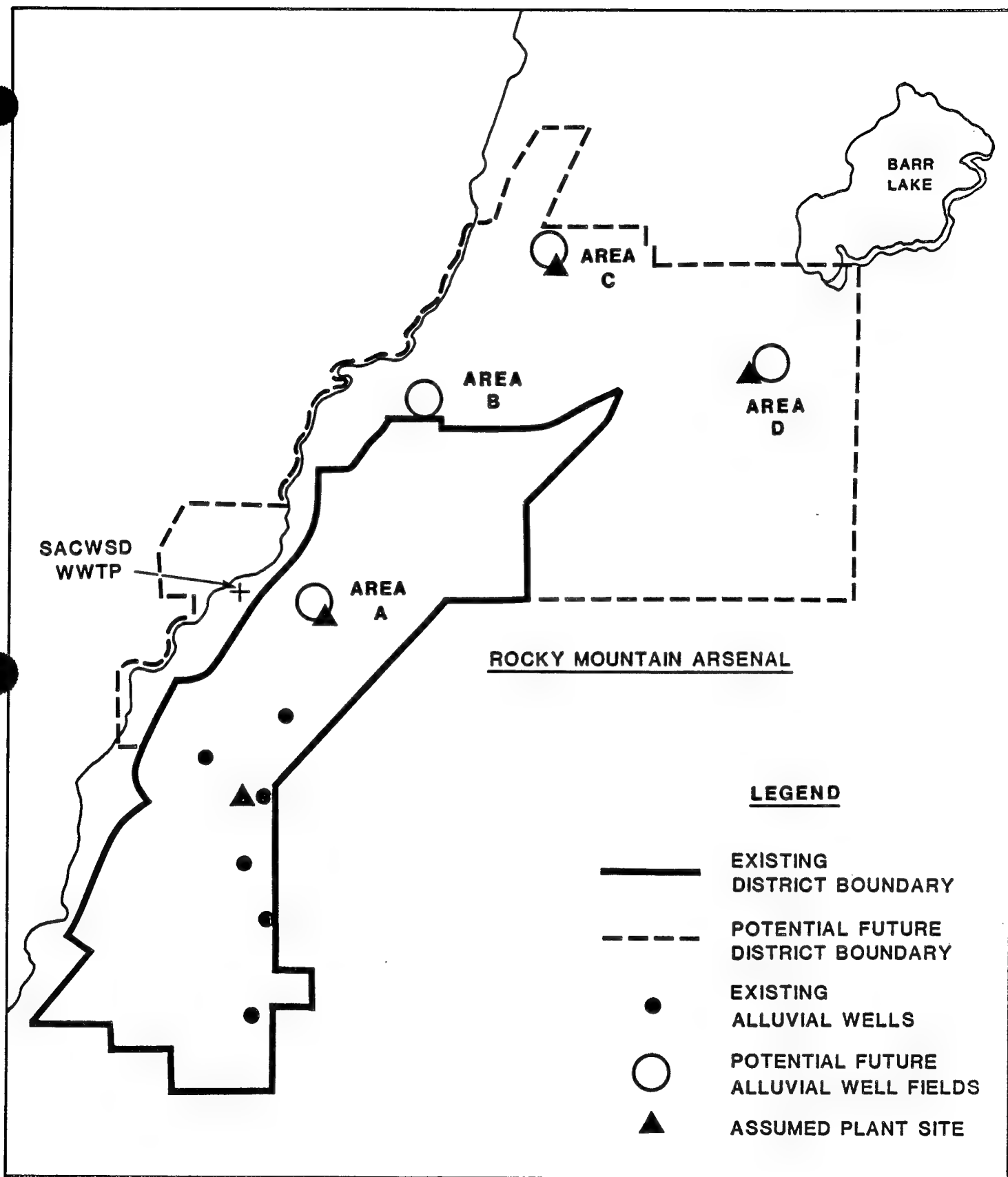
Steel Pressure Vessels		
Virgin Carbon	=	\$1.00/lb
Carbon replacement	=	\$1.40/lb
EBCT	=	15 min.
Maximum Vessel Diameter	=	12 ft.
Loading Rate	=	5 gpm/ft ²

Air Stripping

Forced draft packed tower with concrete wetwell and pump station		
TCE Air to Water Ratio	=	30
DIMP Air to Water Ratio	=	1000
Loading Rate with TCE	=	20 gpm/ft ²
Loading Rate with DIMP	=	4 gpm/ft ²
Blower Efficiency	=	50%
Pump Efficiency	=	75%
Wetwell Detention Time	=	15 min.
Sodium Hexametaphosphate	=	2 mg/l at \$0.80/lb

GAC for Air Pollution Control

Carbon Usage = Liquid phase adsorption usage
Air heated to reduce humidity from 95% to 70%



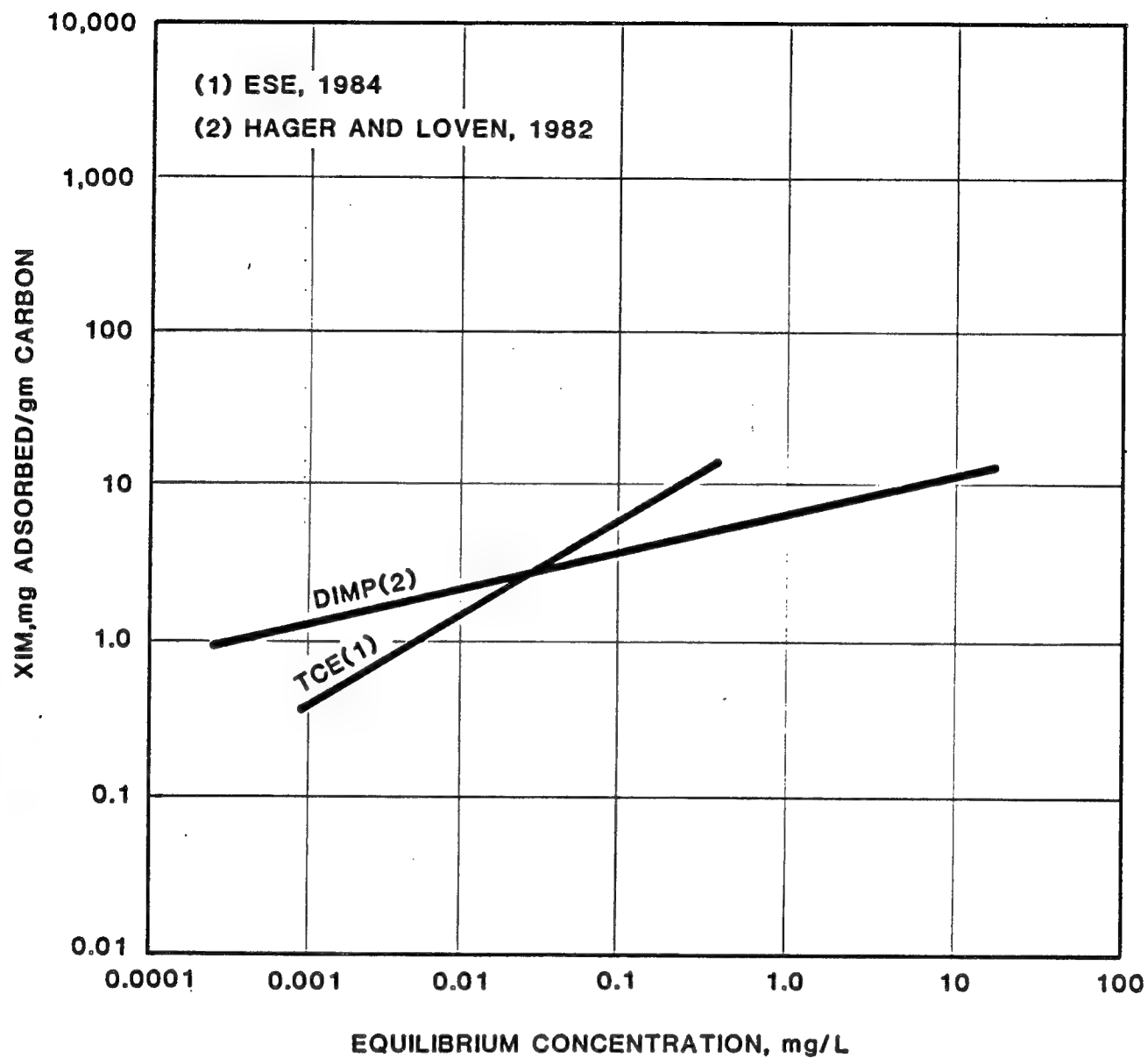
CENTRALIZED ORGANICS REMOVAL PLANTS
FIGURE 5-4

Evaluation of Alternatives for Organic Contaminant Removal

Annual operating costs were based on an average well usage of 40 percent or a historical District maximum day to average day peaking factor of approximately 2.5 (JMM, 1985). To simplify GAC operating cost calculations, it was assumed that GAC has the same adsorption capacity for TCE and DIMP. The isotherms for TCE and DIMP given in Figure 5-5 show this assumption to be reasonably accurate. Based on information provided by Calgon, the capacity of GAC for gas phase was assumed to be the same as that for liquid phase adsorption as a result of the higher air temperatures and humidity. The Henry's constants for TCE and DIMP were assumed to be 600 and 2 atmospheres, respectively. The DIMP constant was calculated from a solubility of 1,500 mg/l and vapor pressure of 0.28 mmHg developed by Rosenblatt (1975).

Table 5-3 lists the flows and assumed concentrations of organic contaminants for each of the ground water supplies. The assumed concentrations are higher than actual observed levels to account for anticipated higher levels as a result of maximum usage of ground water supplies. It was assumed that the Area A ground water supply contained only trichloroethylene. As previously indicated however, there is some potential for DBCP and DIMP contamination at this well site. If contamination of Area A with DIMP and DBCP is assumed, the cost of air stripping relative to the cost of GAC would increase substantially. The impact on GAC total cost would be negligible. The assumed treated water quality was to reduce TCE below 5 ug/l and DIMP below its reported detection level of 1.9 ug/l (ESE, 1985). Tables 5-4 through 5-7 summarize the capital, annual operating costs, total present worth and unit treatment costs for each of the three alternatives.

Air stripping with decentralized facilities at each well site is the least expensive with regard to capital and total unit treatment costs for both existing wells and potential future wells. These estimates suggest that, based on the assumption given, DIMP may be cost-effectively removed from future potential wells by air stripping. This is largely due to the fact that over 50 percent of the future potential supply is from Area A which was assumed to have no DIMP contamination. In practice, there are a number of technological problems that



TCE & DIMP ISOTHERMS
FIGURE 5-5

TABLE 5-3
FLows AND WATER QUALITY ASSUMED
FOR COST ESTIMATES

	Q (cfs)	Concentration Criteria for Design (ug/l)	Observed Range
Existing Alluvial Wells			
2	2.22	100 TCE	5 to 31 ug/l TCE
3	4.66	100 TCE	7 to 46 ug/l TCE
5	7.78	20 TCE	3 to 11 ug/l TCE
14	2.20	100 TCE	2 to 57 ug/l TCE
15	0.69	20 TCE	2 to 4 ug/l TCE
16	1.78	20 TCE	6 to 15 ug/l TCE
(Same as #5) 17	7.78	20 TCE	2 to 10 ug/l TCE
(Same as # 2 & 3) 18	6.88	20 TCE	1 to 3 ug/l TCE
Future Alluvial Wells			
Area A	25.6	20 TCE	1 to 4 ug/l TCE
Area B	2.7	350 DIMP	10 to 340 ug/l DIMP, 0 to 0.3 ug/l DBCP, 55 ug/l CHCl ₃
Area C	10.7	10 DIMP	6 ug/l DIMP
Area D	9.3	10 DIMP	No Data

TABLE 5-4

ESTIMATED TREATMENT COSTS FOR ORGANIC CONTAMINANT REMOVAL
FOR EXISTING AND FUTURE ALLUVIAL WELLS

Capital Cost (\$ Thousands)

ENR = 3500

	Air Stripping	Air Stripping with Air Pollution Control	GAC
Centralized Existing Wells ¹	2,200	3,200	5,600
Decentralized Existing Wells ²	2,000	3,700	6,300
Centralized Future Wells ³	5,800	19,000	11,000
Decentralized Future Wells ⁴	5,000	18,000	11,000

1 Centralized existing wells assumes combined flow of well No. 2, 3, 5, 14, 15 and 16 with treatment facilities at wells No. 17 and 18

2 Decentralized existing wells assumes treatment facilities at each well

3 Centralized future wells assumes a treatment facility in area A, D and B + C

4 Decentralized future wells assumes treatment facilities at each area

TABLE 5-5

**ESTIMATED TREATMENT COSTS FOR ORGANIC CONTAMINANT REMOVAL
FOR EXISTING AND FUTURE ALLUVIAL WELLS**

Operation and Maintenance Cost (\$Thousands per Year)

ENR = 3500

	Air Stripping	Air Stripping with Air Pollution Control	GAC
Centralized Existing Wells ¹	43	640	710
Decentralized Existing Wells ²	44	640	720
Centralized Future Wells ³	380	5,400	1,600
Decentralized Future Wells ⁴	380	5,300	1,500

1 Centralized existing wells assumes combined flow of well No. 2, 3, 5, 14, 15 and 16 with treatment facilities at wells No. 17 and 18

2 Decentralized existing wells assumes treatment facilities at each well

3 Centralized future wells assumes a treatment facility in area A, D and B + C

4 Decentralized future wells assumes treatment facilities at each area

Evaluation of Alternatives for Organic Contaminant Removal

TABLE 5-6

ESTIMATED TREATMENT COSTS FOR ORGANIC CONTAMINANT REMOVAL FOR EXISTING AND FUTURE ALLUVIAL WELLS

Total Present Worth (\$ Thousands)

ENR = 3500

	Air Stripping	Air Stripping with Air Pollution Control	GAC
Centralized Existing Wells ¹	2,700	10,000	14,000
Decentralized Existing Wells ²	2,500	11,000	14,000
Centralized Future Wells ³	10,000	80,000	29,000
Decentralized Future Wells ⁴	9,300	77,100	28,000

1 Centralized existing wells assumes combined flow of well No. 2, 3, 5, 14, 15 and 16 with treatment facilities at wells No. 17 and 18

2 Decentralized existing wells assumes treatment facilities at each well

3 Centralized future wells assumes a treatment facility in area A, D and B + C

4 Decentralized future wells assumes treatment facilities at each area

TABLE 5-7

ESTIMATED TREATMENT COSTS FOR ORGANIC CONTAMINANT REMOVAL
FOR EXISTING AND FUTURE ALLUVIAL WELLS
Unit Costs* (\$/1000 Gallons)

	Air Stripping	Air Stripping with Air Pollution Control	GAC
Centralized Existing Wells ¹	13	51	66
Decentralized Existing Wells ²	12	53	70
Centralized Future Wells ³	20	160	56
Decentralized Future Wells ⁴	18	150	54

* Based on a 30 year amortization at 8 percent interest.

1 Centralized existing wells assumes combined flow of well No. 2, 3, 5, 14, 15 and 16 with treatment facilities at wells No. 17 and 18

2 Decentralized existing wells assumes treatment facilities at each well

3 Centralized future wells assumes a treatment facility in area A, D and B + C

4 Decentralized future wells assumes treatment facilities at each area

would have to be resolved to design an operational air stripping facility for DIMP removal. As previously indicated, air pollution control may be required. However, more stringent regulation of air pollutants and concern of nearby residences may dictate the use of air pollution control.

For the existing ground water supply, air stripping with air pollution control is slightly less expensive with respect to capital cost and total present worth than GAC.

For future potential District wells, GAC is less expensive than air stripping with air pollution control. This is due to the extremely high volumes of air required to strip DIMP. The capital and operating costs of air pollution control is closely related to the air flow to be treated. It was assumed that an air to water ratio of 1000 to 1 would be required to achieve reasonable removal efficiencies, whereas with TCE, only a 30 to 1 air to water ratio would be required. Decentralized facilities for air stripping with air pollution control is less expensive than centralized treatment for future wells but not for existing wells, as a result of the greater distance between well fields in the future District area. Similarly, centralized GAC facilities for the existing wells appear to be more cost-effective.

For the existing wells, air stripping and air stripping with air pollution control are more cost effective than GAC. However, because of the potential for contamination with less volatile organics such as DBCP, and DIMP, these alternatives are not considered to be as conservative as GAC. GAC was the least expensive alternative for treatment of ground water in the future District alluvial ground water supply.

In spite of the lower costs of air stripping for treatment of existing ground water supplies, it is recommended that a GAC be considered for both existing and future water supplies. The justification for this recommendation is:

- o Air stripping will not ensure effective removal of nonvolatile

Evaluation of Alternatives for Organic Contaminant Removal

organics that may ultimately migrate into the ground water supply.

- o Granular activated carbon would provide a single treatment appropriate for treatment of existing and future wells. The District's operations staff would therefore be able to operate and maintain similar facilities. As a result, more reliable operation of the facilities would be expected.
- o GAC facilities would be less visible and aesthetically more attractive than air stripping facilities.
- o Granular activated carbon facilities could be sheltered in a architecturally treated building. Air stripping facilities, on the other hand, would require towers 30 or more feet high.
- o Potential environmental problems with air pollution are eliminated with GAC.

CHAPTER 6

CHAPTER 6

EVALUATION OF SOFTENING ALTERNATIVES

This chapter evaluates the feasibility of softening the District's ground water supply. With an average hardness of 420 mg/l, the District's alluvial supply is classified as a very hard water in accordance with the U.S. Geological Survey Classification of Hardness. Further, this level is in excess of AWWA's drinking water goal of less than 80 mg/l. Normally, excessive hardness is removed by softening to reduce detergent demand and improve washing conditions, and to increase the life of domestic water heaters. There are also possible cost savings to industrial users that require low hardness for boiler water and cooling water make-up and other process needs. A previous study for the District examined various alternatives for softening (SGI, 1982).

In this chapter, cost estimates are developed for softening by sodium ion exchange and lime-soda ash. Reverse osmosis (R.O.), a process normally used for demineralization, was also considered. However, because of the relatively high hardness of the District's ground water supply, reverse osmosis would most likely have to be preceded by some other softening process or the addition of a significant amount of acid to prevent excessive scaling of the membranes. The already high cost of R.O. would include additional major costs for this application. For this reason, R.O. was not considered to be cost competitive with lime softening or ion exchange softening. Only ion exchange and lime-soda ash are reviewed in detail below.

WATER QUALITY

Table 3-6 summarizes the historical water quality for the District's water supply with regard to constituents relevant to softening. The hardness and alkalinity of the District's existing alluvial wells are generally uniform. Magnesium concentrations appear to be somewhat variable, depending on the well location. Total hardness and magnesium in the future potential alluvial ground water

Evaluation of Softening Alternatives

supply are higher than existing wells. The cost of softening the potential future water supply will therefore be higher. The District's deep well water hardness levels are sufficiently low such that softening is not required.

Table 6-1 summarizes the water quality criteria used to estimate treatment costs. The values for the raw water represent approximate concentrations associated principally with the 77th and Pontiac/Quebec wells. The treated water quality criteria assumes a finished water hardness of 80 mg/l as calcium carbonate in accordance with the AWWA goal. Concentrations of calcium and magnesium are representative of concentrations typically achieved with conventional softening processes utilizing lime and soda ash. The same treated water concentrations were assumed for estimates of ion exchange so that costs would be representative of an equivalent treated water quality.

TABLE 6-1
ASSUMED TREATED WATER QUALITY FOR
SOFTENING COST ESTIMATES
(mg/l as CaCO_3)

	Raw Water	Treated
Total Alkalinity	260	40
Calcium	340	60
Magnesium	80	20
pH (units)	7.8	8.2*

* In practice the effluent pH may be greater than 8.4 to maintain a positive Langlier index and will ultimately depend on the corrosivity of the treated water and the District's method of corrosion control.

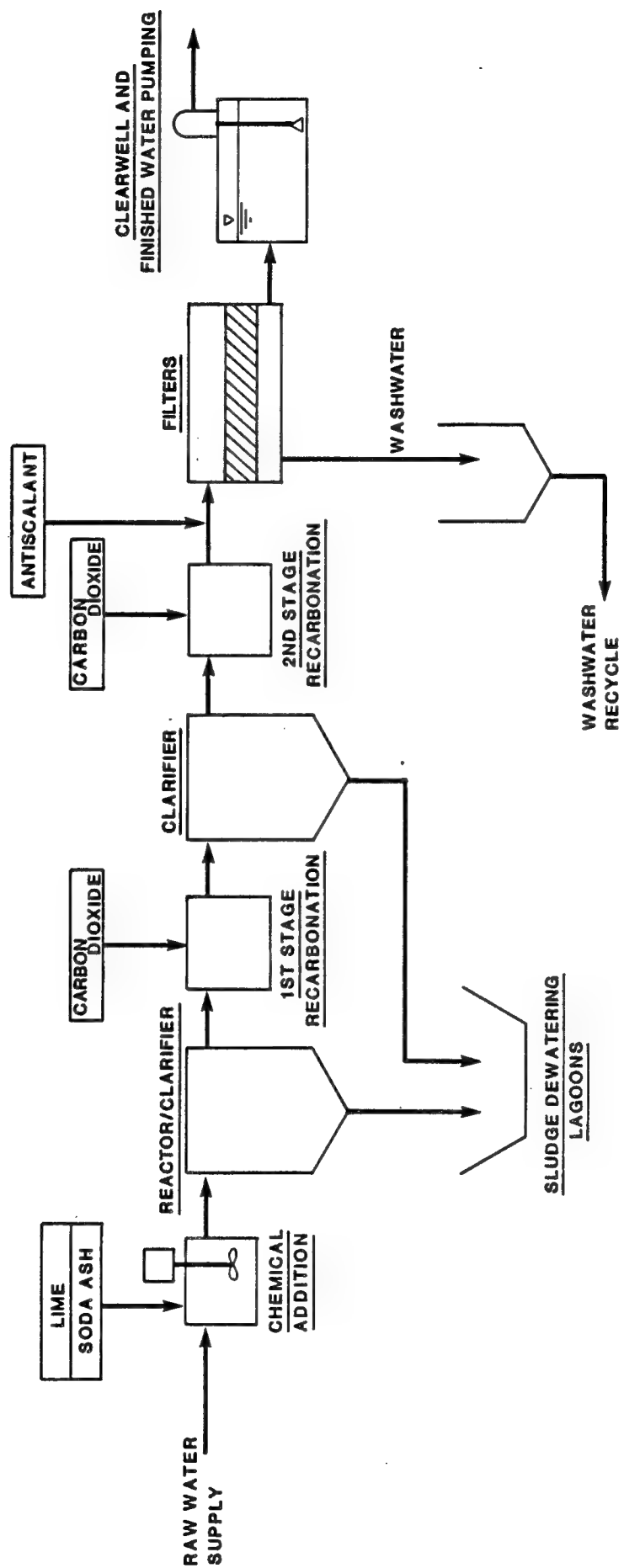
Evaluation of Softening Alternatives

The assumed concentrations for treated water quality are conservative with respect to treatment costs. In actual practice, the District may operate the treatment facility such that the total hardness is significantly higher than the 80 mg/l suggested in Table 6-1. The District may find, for example, that consumer preference and control of corrosivity dictate a higher treated water hardness. The treated water quality goals for softening will also impact the treatment scheme and process units selected. These issues are discussed in greater detail in the following section.

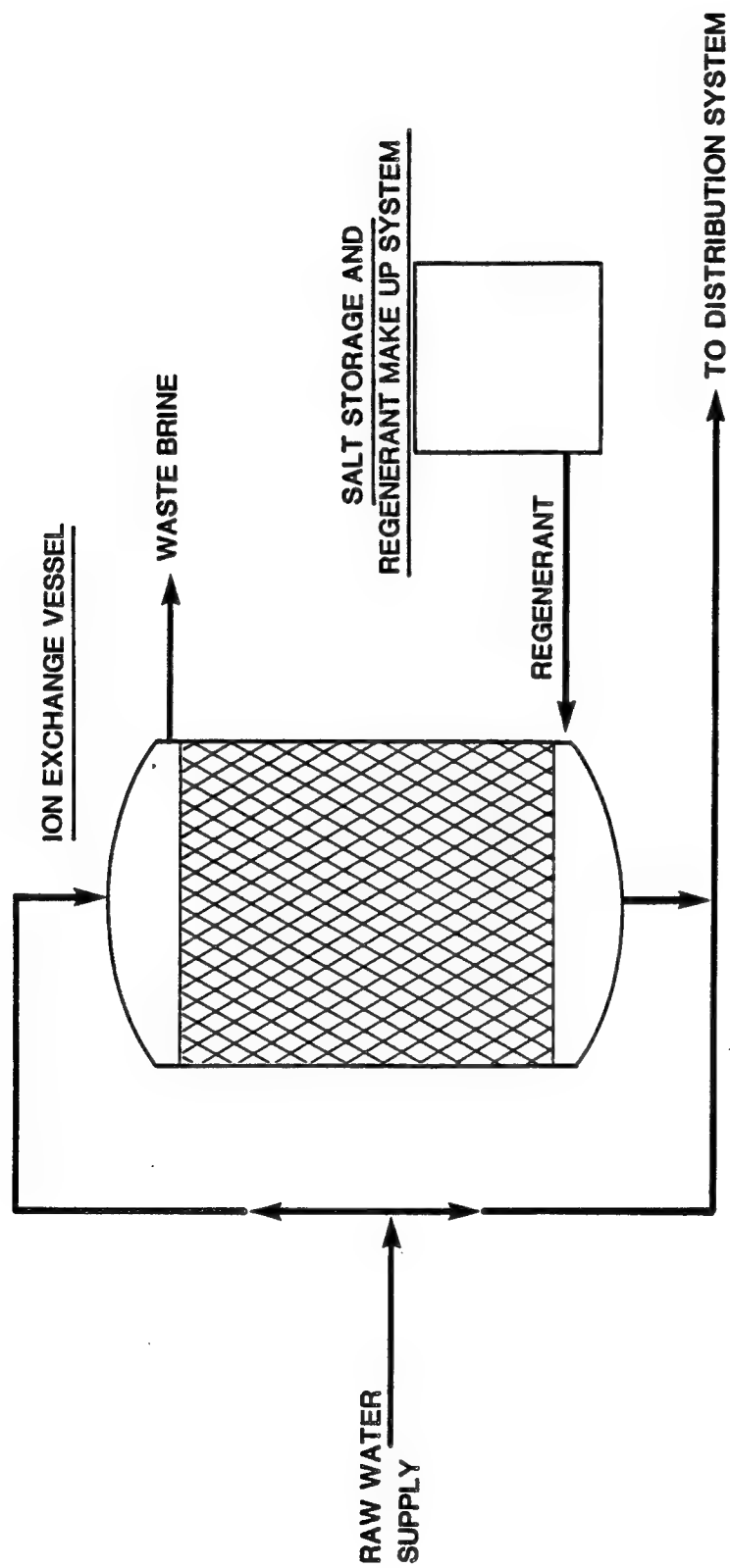
ALTERNATIVE TREATMENT PROCESSES

The assumed treatment schemes for lime-soda ash softening and ion exchange softening are shown in Figures 6-1 and 6-2, respectively. The basic treatment scheme for lime soda ash softening utilizes two-stage recarbonation. This scheme is one of the most conservative with respect to design and cost. A number of other systems are available, including split-stream treatment, single stage softening or a combination of lime softening and ion exchange. The appropriate lime softening process can only be determined by a predesign level study specifically for lime softening. Such a study should include, as a minimum, an evaluation of land availability for the construction site, additional water quality analyses to characterize the seasonal variability of the constituents listed in Table 3-6 and an evaluation of treated water quality goals based on consumer preference and with consideration of the impact of the corrosivity of the treated water.

Sludge or brine disposal in demineralization or softening processes is typically a significant cost and an environmental issue. For the lime-soda ash softening, it was assumed that lime sludge generated by the process would be dewatered in lagoons. Dried sludge would then be trucked to a landfill. The feasibility of this approach for dewatering depends on the available land at the plant site. If sufficient land is not available or if lime recalcination is utilized, the lime softening sludge would be dewatered mechanically. The issue of sludge



LIME-SODA ASH SOFTENING
FIGURE 6-1



SODIUM ION EXCHANGE SOFTENING

FIGURE 6-2

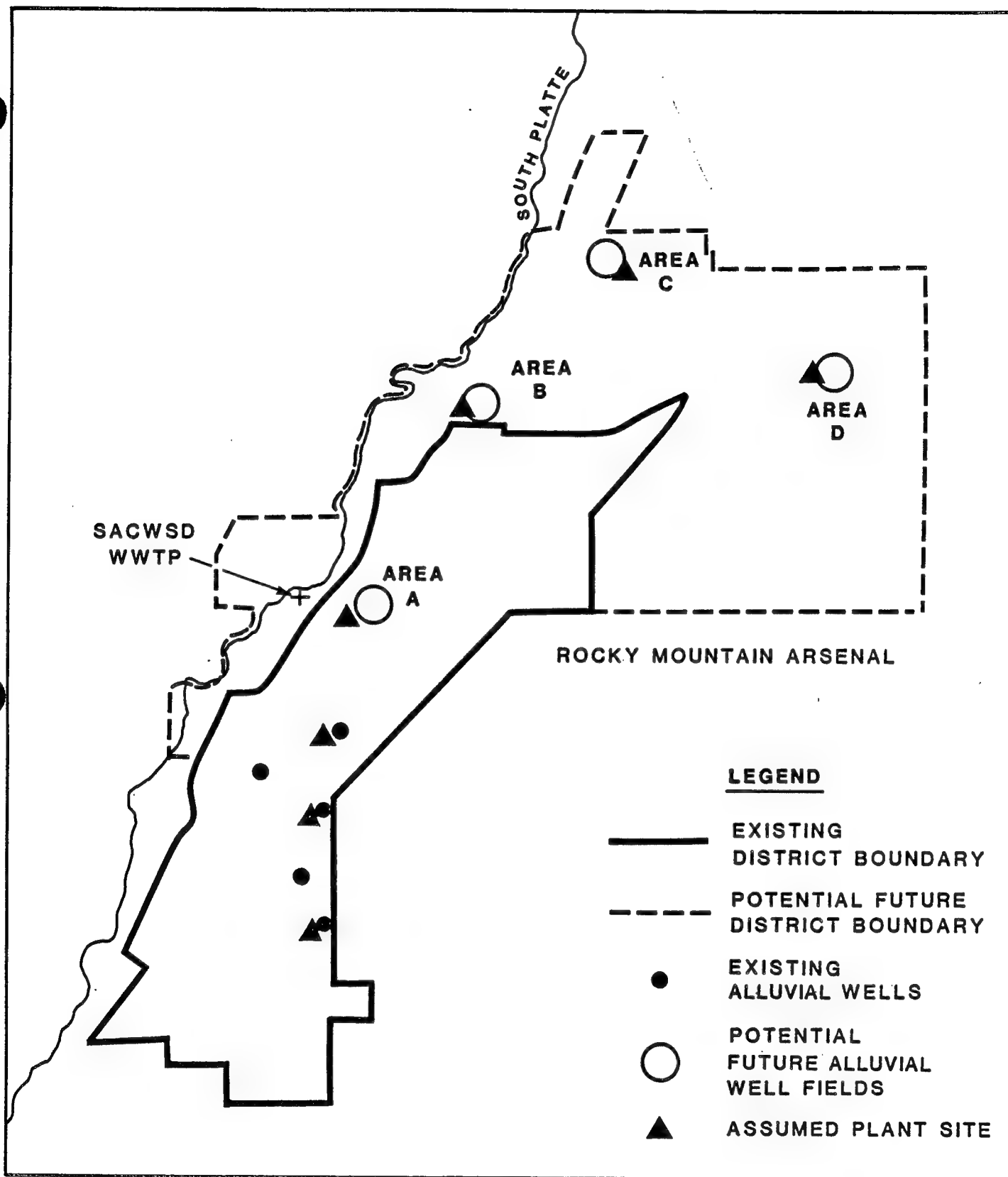
Evaluation of Softening Alternatives

dewatering with possible recalcination should also be evaluated in a predesign study for softening.

The assumptions for process design criteria for lime softening and ion exchange softening are summarized in Tables 6-2 and 6-3. Lime softening chemical dosages and associated sludge quantities calculated from Caldwell-Lawrence diagrams are given in Table 6-4.

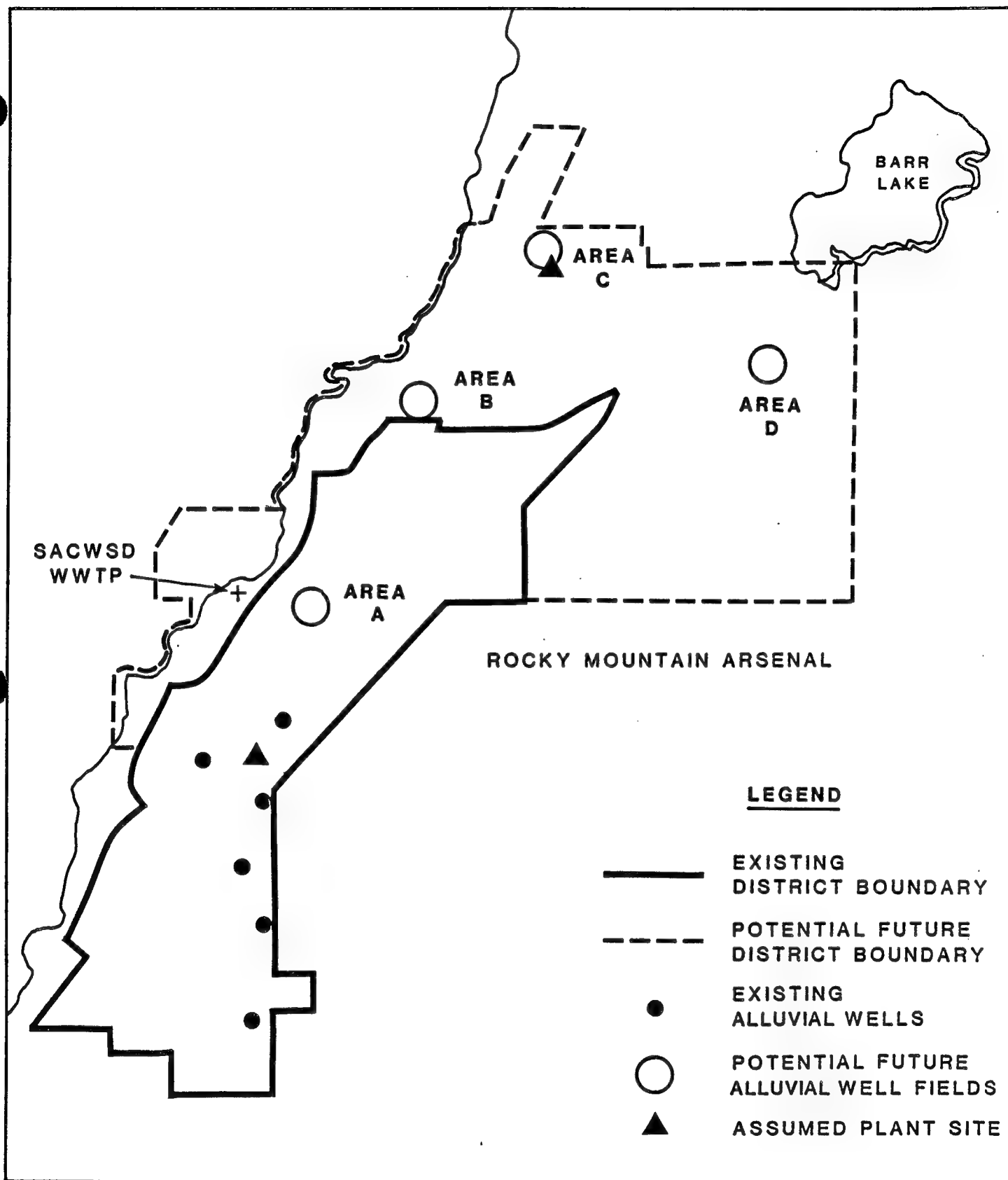
Costs were determined for centralized and decentralized treatment facilities for softening. Figures 6-3 and 6-4 illustrate the locations of the facilities for centralized and decentralized treatment. For centralized treatment, it was assumed that two treatment facilities would be provided. The southern facility would treat water from the existing alluvial wells and would be expanded in the future to treat ground water from Area A wells. The plant could be located in the vicinity of the 77th Street wells or at a location more central to future Area A and the 77th Street Wells. Depending on the processes utilized, a location outside of the highly developed portion of the District may be more advantageous with regard to site access and future expansion.

The northern treatment plant would be located at Area C and would receive raw water from Areas B and D wells. It was assumed that the plant serving the northern future District area would be provided with adequate onsite clearwell storage to meet peak demands. Therefore, piping costs from the plant back to the well site were not included. In this regard, it was assumed for the northern plant alternative that distribution system piping would be sized to provide adequate distribution from the plant. For the southern plant serving the existing District wells, it was assumed that storage requirements would be provided by the District's existing reservoirs. Therefore, piping costs were included for transmission to and from the existing well sites.



DECENTRALIZED SOFTENING PLANTS

FIGURE 6-3



CENTRALIZED SOFTENING PLANTS
FIGURE 6-4

Evaluation of Softening Alternatives

TABLE 6-2

ASSUMED CRITERIA FOR LIME-SODA ASH SOFTENING

Item	Units	Value
Flow, Existing Wells	mgd	12.5
Flow, Future Wells	mgd	31
Rapid Mix		
G	Sec ⁻¹	300
Detention time	min.	1.0
Reactor Clarifiers		
Surface loading	gpm/ft ²	1.0
1st Stage Recarbonation		
Detention time	min.	15
2nd Stage Clarifier		
surface loading	gpm/ft ²	0.75
2nd Stage Recarbonation		
Detention time	min.	15
Filtration Rate	gpm/ft ²	5
Backwash Rate	gpm/ft ²	18
Clearwell Storage	hrs.	2
Sludge Lagoons	cu ft/mgd	5000
Dry Sludge	%/solids	30
Distance to Landfill	miles	20

Evaluation of Softening Alternatives

TABLE 6-3

ASSUMED CRITERIA FOR SODIUM ION EXCHANGE SOFTENING

Item	Units	Value
Pressure vessels	-	-
Regenerated use	lb. salt/gal. water treated	0.01
Process Effluent Hardness*	mg/l	0

*Softened portion of flow then blend to produce 80 mg/l plant effluent hardness

TABLE 6-4

LIME SOFTENING CHEMICAL USAGE AND RESIDUAL SOLIDS ESTIMATED FROM CALDWELL-LAWRENCE DIAGRAMS

	mg/l as CaCO ₃	mg/l as Constituent
Lime used	380	213
Soda Ash	100	106
Carbon Dioxide	81	35
Calcium Carbonate Sludge	660	660
Magnesium Hydroxide Sludge	60	35

The locations of facilities for decentralized treatment are shown in Figure 6-4. Due to economies of scale, treatment facilities at each well site are not cost effective. Therefore, the costs were based on seven water treatment plants, each serving well fields within a reasonable distance from the treatment plant.

Evaluation of Softening Alternatives

IMPACT ON SODIUM

An amendment to the EPA Primary Drinking Water Standards (EPA, 1980) recommends an optimum level for sodium of 20 mg/l or less based on a number of recent studies suggesting correlations between sodium and heart disease. However, the EPA indicated evidence was not sufficient to warrant establishment of an MCL. Rather, recommendations were made for monitoring of sodium and for modifications in treatment to reduce high levels of sodium.

The concentration of sodium in the District's existing alluvial supply ranges from 100 to 140 mg/l (SGI, 1982). In the lime-soda ash process, approximately 0.84 mg/l of sodium is added for every mg/l of soda ash. For the soda ash dosage given in Table 6-4, the sodium concentration would increase by about 92 mg/l.

To achieve the same level of softening with sodium ion exchange, the sodium concentration of the alluvial water would increase by 146 mg/l. From the standpoint of the potential health impact from sodium, lime soda ash is clearly the superior. Further, sodium addition could be eliminated entirely from the lime softening process by removing only carbonate hardness.

COST COMPARISON

Table 6-5 summarizes softening cost for centralized and decentralized plants. For future centralized facilities, lime-soda ash softening is less expensive than ion exchange. Economies of scale are not realized for large pressurized ion exchange tank systems. While in general ion exchange appears to be less expensive than lime softening, the cost differential between ion exchange and lime softening may be less than indicated since the lime-soda ash plant design ultimately used may not include all of the unit processes assumed. For example, if the District decides to lime soften to a hardness level higher than the 80 mg/l suggested and /or chose a less conservative system design such as single-stage softening, then considerable cost savings would be realized.

TABLE 6-5
ESTIMATED COSTS FOR SOFTENING ALTERNATIVES

	Lime-Soda Ash			Sodium Ion Exchange				
	Capital (\$1000)	O&M (\$1000/Yr)	Present Worth (\$1000)	Unit Cost (\$/1000 gal)	Capital (\$1000)	O&M (\$1000/Yr)	Present Worth (\$1000)	Unit Cost (\$/1000 gal)
Existing Wells								
Centralized	7,510	907	17,700	86	4,300	704	12,200	72
Decentralized	12,400	1,140	25,200	123	4,740	511	10,500	97
Future Wells								
Centralized	12,800	1,270	27,100	53	8,240	1,700	27,300	65
Decentralized	17,500	2,450	45,100	88	7,830	1,810	28,200	67

Evaluation of Softening Alternatives

In addition, the cost of brine disposal for ion exchange was not included. In an earlier study by Sellards & Grigg, Inc. (1982), ion exchange softening was shown to be more expensive than lime-soda ash because of the additional cost of waste brine treatment. When the District used ion exchange, the waste brine was disposed into the District's sanitation system. The fees assessed for the use of the sewer system would increase the cost of ion exchange. Although no clearly defined state restrictions on disposal of brine presently exists, substantial costs may be involved depending on future restrictions for brine disposal and the possible impact of brine on District's wastewater treatment operations.

Because design considerations of the lime system and brine disposal costs for ion exchange would be expected to decrease the cost differential between the two softening treatments and because of the potential health impact from sodium, lime softening is the recommended softening method.

CHAPTER 7

CHAPTER 7

RECOMMENDED TREATMENT ALTERNATIVES

Based on the preliminary evaluation of the treatment alternatives presented in Chapter 5 and 6, two potential treatment alternatives are recommended for the District's consideration. One alternative is to provide for granular activated carbon adsorption facilities to remove organic contaminants without softening. The second alternative is to provide treatment facilities for granular activated carbon adsorption combined with lime softening. These two alternatives are reviewed with regard to cost and implementation.

GRANULAR ACTIVATED CARBON ADSORPTION FACILITIES WITHOUT SOFTENING

The preliminary cost estimates presented in Chapter 5 indicated that the most cost effective arrangement of treatment plants is to provide a central GAC facility to treat existing alluvial wells and decentralized facilities at each of the four proposed future well fields. The centralized plant for the existing District area would be located in the vicinity of the 77th Street wells as shown in Figure 5-4.

Costs

Table 7-1 gives the basic design criteria used for the GAC cost estimates. Table 7-2 lists the costs for each plant site. Capital and O&M costs were developed from EPA cost curves (EPA, 1979, Adams, 1985). General assumptions for developing costs are consistent with those listed in Table 5-2. Total capital cost to provide treatment for the existing alluvial wells is estimated to be \$5.6 million. Based on accepted degree of accuracy for this level of estimate, the cost for these facilities may be as high as \$7.3 million or as low as \$4.5 million. This range should be taken into consideration if these costs are to

be used for budgeting. This figure includes all costs associated with design and construction of facilities to treat and distribute the indicated well capacity. Capital costs do not include District expenses for project administration.

TABLE 7-1
ASSUMED CRITERIA FOR GAC ADSORPTION

Item	Units	Value
Vessels	-	Steel pressure
Maximum Diameter	ft.	12
Load Rate	gpm/ft ²	5
Empty Bed Contact Time (EBCT)	min.	15
Hexametaphosphate Dose	mg/l	1.0

TABLE 7-2
SUMMARY OF ESTIMATED COSTS FOR GAC ADSORPTION FACILITIES

Location	Wells Treated	Flow Treated (gpm)	Capital (\$1000)	Total O&M (\$1000/Yr)	Total Present Worth (\$1,000)	Unit Cost (\$/1000 Gallons)
Centralized Plant to Treat Existing District Wells	#14, #15, #16, #18, #2, #3 #5, #17	8,679	5,600	707	13,600	66
Potential Future Wells						
Area A	-	11,494	5,610	774	14,300	53
Area B	-	1,203	714	157	2,480	87
Area C	-	4,795	2,460	297	5,800	51
Area D	-	4,175	2,190	261	5,140	52
Total for Potential Future Wells		21,667	10,974	1,489	27,720	54

ENR = 3500

Present worth and unit costs are based on 30 year amortization at 8 percent interest.

Feasible Treatment Alternatives

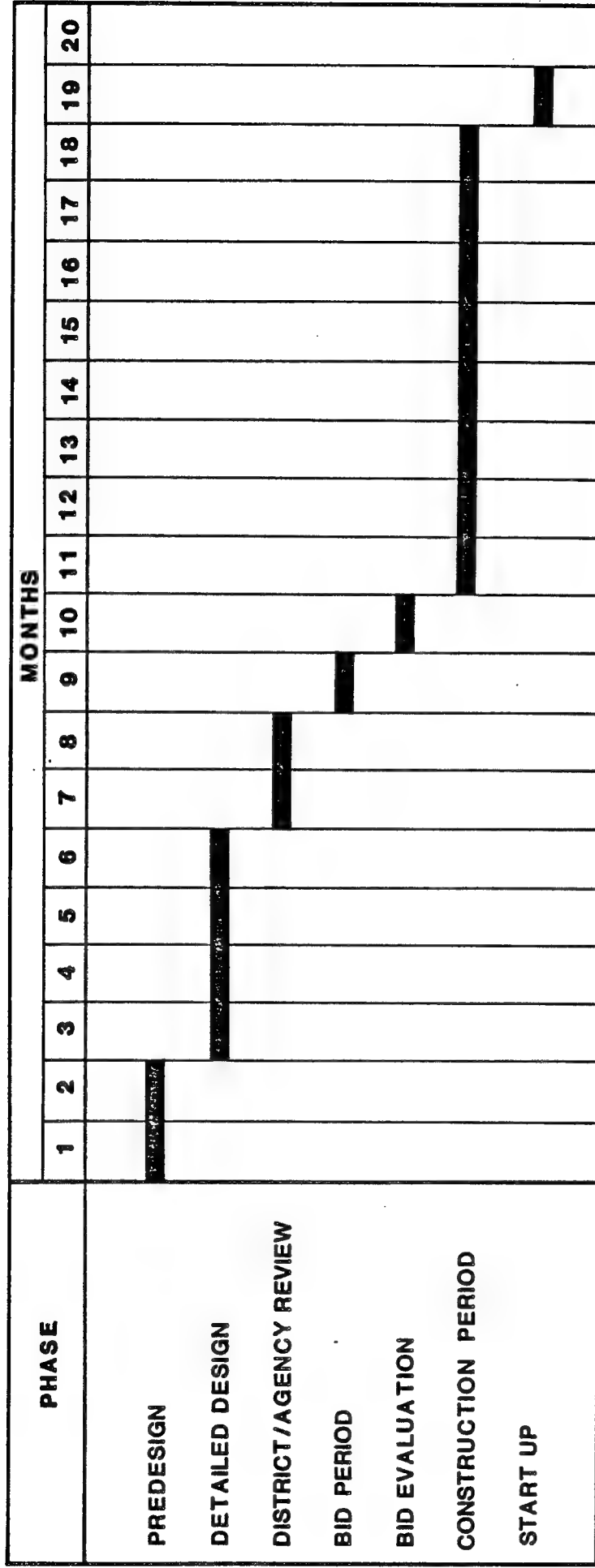
Capital costs to equip the future potential District wells is an estimated \$11 million based on a Denver ENR of 3,500. The actual costs of these facilities would be in the range of \$8.8 to \$14.3 million. Unit treatment cost for future potential wells is less than existing well costs due to economies of scale, the assumed lower concentrations of organic contaminants, and reduced piping costs.

Preliminary Implementation Schedule

Figure 7-1 presents a preliminary schedule for implementing this alternative.

It is envisioned that two months would be required for a detailed predesign study for the facilities. The predesign study would evaluate the following:

1. **GAC usage rates.** These can be estimated from operational data from the temporary treatment system or pilot tests.
2. **The feasibility of District-operated centralized GAC regeneration facility.** The usage rate for the existing wells determined from Task 1 above, may not be adequate to justify a regeneration facility. However, the addition of further GAC facilities for future potential wells may justify a District-operated regeneration facility.
3. **The performance of the interim GAC adsorption facilities.** These units should be examined with regard to potential for calcium carbonate scaling and with regard to the necessity of pre- or post disinfection.
4. **Potential sites for facilities.**
5. **Well pump capacities.** Identify modifications, if required, to achieve adequate flow. This investigation should be done in conjunction with the District's hydrogeologist, and should take into account the seasonal variability in well yield.



PRELIMINARY IMPLEMENTATION SCHEDULE
FOR EXISTING ALLUVIAL WELLS
GAC ADSORPTION FACILITIES

FIGURE 7-1

Feasible Treatment Alternatives

Detailed design would begin following the completion of the predesign evaluation. It is envisioned that three to four months would be required for detailed design of facilities. Two months have been allocated for review of the design by the District and agencies responsible for building code review. Additional review time may be required for review by the Colorado Department of Health or the Environmental Protection Agency. Two months are shown for the bid period and bid evaluation prior to award of contract. The construction period is estimated to be approximately 8 months. One month has been assumed for plant startup. Prepurchase of long lead time items such as the GAC adsorption vessels by the District may accelerate the schedule somewhat.

GAC ADSORPTION/LIME SOFTENING COMBINED

This alternative consists of two centralized treatment facilities. One would principally treat the existing District wells and the other would treat future potential District wells. It is assumed that economies of scale of the treatment plant would dominate as in the case of softening alone. Therefore, the location of the plants would be the same as those shown in Figure 6-4 for softening alone. Figure 6-4 shows the facility located along 80th Street, a location central to the 77th Street wells and future potential well field A. It is envisioned that this facility would treat the existing wells with an initial capacity of 12 to 15 mgd. The facility would be expanded to 20 to 30 mgd to treat the additional flow from well field A.

Land requirements for a plant with an ultimate capacity of 30 mgd is estimated to be 3 to 6 acres. The actual land requirements will depend on the method used for sludge dewatering. Mechanical dewatering will significantly reduce land requirements. Several advantages to locating the facility to the north of 80th Street are apparent. The facility would be closer to the future Area A well fields, which have a projected capacity of approximately 16.5 mgd, thus there would be a considerable cost savings for piping to and from the water treatment plant. In addition, the plant would be located outside the more densely developed area near the 77th Street wells. Furthermore, land may be more accessible and less expensive, possibly allowing more space for site layout.

Feasible Treatment Alternatives

GAC facilities can be designed to either precede or follow softening facilities. There are advantages and disadvantages to both arrangements and their feasibility depends on potential problems in the scaling of the GAC and contamination of softening waste sludge with nonvolatile organics.

There is potential for nonvolatile organics such as DIMP to be absorbed and removed with lime softening sludge. This is beneficial with respect to GAC in that part of the removal is achieved by the softening process. However, this may present a problem in the disposal of the lime sludge and the concentration of organics that might be anticipated. If lime sludge disposal appears to be a problem, then it would be appropriate for GAC to precede the softening process. Scaling of the GAC may occur as a result of loss of carbon dioxide and increased pH if GAC precedes softening; however, this can be partially avoided by utilizing pressure vessels.

The actual sequence of the GAC and softening processes is not of great significance for feasibility level cost estimates. However, the sequence and the various associated issues must be resolved by bench or pilot scale testing, if necessary, prior to or during the predesign stage.

Costs

Basic process criteria for lime softening and GAC assumed for cost estimates are listed in Table 6-6 and 7-1, respectively. Costs for centralized GAC/lime softening facilities are summarized in Table 7-3. These costs are somewhat conservative in that they are based on the sum plus pipe costs of the individual costs for lime-soda ash softening and GAC developed in Chapters 5 and 6. Some cost savings may be realized from reduced site costs and staff labor costs.

TABLE 7-3
SUMMARY OF ESTIMATED COSTS FOR CENTRALIZED GAC/LIME SOFTENING FACILITIES

Location	Wells Treated	Flow Treated (gpm)	Capital Cost (\$1000)	Total O&M (\$1000/Yr)	Total Present Worth (\$1,000)	Unit Cost (\$/1000 Gallons)
80th Street or 77th & Pontiac	2, 3, 5, 17, 14, 16, 15, 18	8,679	11,200	1,270	25,600	124
Area C	Wells from Areas B, C, & D*	21,669	21,400	2,860	53,600	104

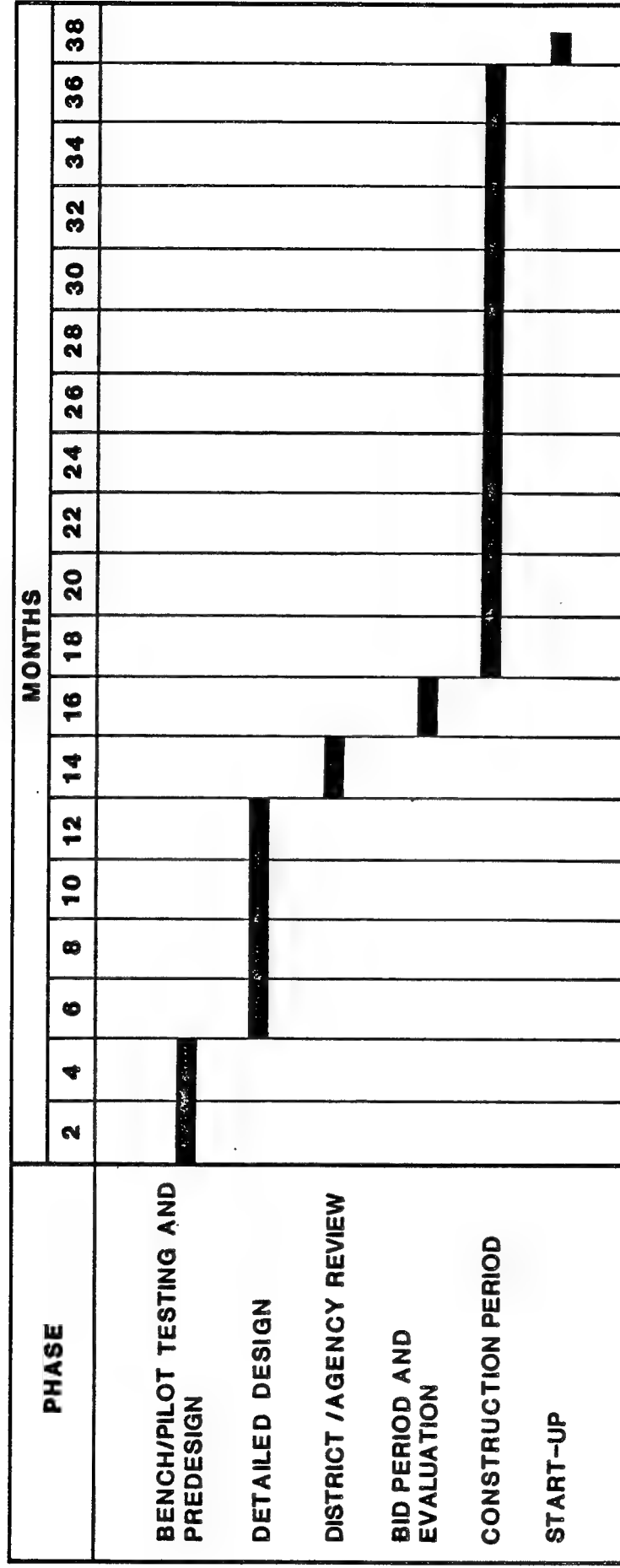
* The 80th Street plant would be expanded to treat 11,500 gpm from Well Field A. Present worth and unit costs are based on 30 year amortization and 8 percent interest.

Implementation Schedule

A preliminary schedule for implementing GAC/lime softening facilities is given in Figure 7-2. The entire schedule for GAC/lime softening is ten months longer than for GAC adsorption facilities. The extension in the overall schedule is due largely to the anticipated longer construction schedule required for concrete work and/or fabrication of package treatment units. In addition, the predesign and design of the facility will require more time.

At least four months should be allocated for bench/pilot scale testing and predesign. The specific areas that need to be addressed at the predesign stage include the following:

1. Bench or pilot scale tests to determine the extent of removal, if any, of organics with lime sludge. This evaluation should specifically consider removal of DIMP, DBCP and other less volatile organics with lime sludge. If it is determined that removal occurs, then issues involved in disposal of the sludge should be considered in detail.
2. Evaluate alternative lime softening processes and process units, including single staged treatment, split stream treatment, lime softening in combination with sodium ion exchange and feasibility of lime recalcination.
3. Evaluate sludge dewatering alternatives.
4. Evaluate land availability and site requirements in conjunction with item 3.
5. Evaluate distribution system piping changes needed to provide water to and from the centralized plants. Examine the need for onsite clearwell storage. This analysis should look specifically at the option of either providing system storage at the treatment plant with



PRELIMINARY IMPLEMENTATION SCHEDULE
 FOR EXISTING ALLUVIAL WELLS
 GAC/LIME SOFTENING FACILITIES

FIGURE 7-2

Feasible Treatment Alternatives

effluent pumping to meet peak demands or redistribution of plant flow to existing system reservoirs with use of existing boosters for meeting peak system demand.

6. Evaluate distribution system hydraulics and determine the necessity for distribution system piping modifications if centralized storage is selected.

A twenty-month construction schedule following a two-month bid period and bid evaluation is envisioned. This construction period should be adequate for construction of the centralized plant for the existing District wells and any system piping modifications.

APPENDIX A

APPENDIX A

LIST OF REFERENCES

Environmental Science and Engineering (ESE), Rocky Mountain Arsenal Off-post Assessment Draft Ground Water Quality Report for Sampling Period December 1984 through January 1985 Volume 1, Prepared for the U.S. Army Toxic and Hazardous Materials Agency (May, 1985).

James M. Montgomery, Consulting Engineers, Inc. (JMM), Cost Estimating Manual (April 1982).

James M. Montgomery, Consulting Engineers, Inc. (JMM), Water and Wastewater System Master Plan Update and System Development Fees, (July, 1985).

Sellards & Grigg, Inc. (SGI), South Adams County Water and Sanitation District Water Treatment Investigation, (September, 1982).

Spronk Water Engineers, Inc. (SWEI), Alternative Water Supply Study, (January, 1986).

EPA, Municipal Environmental Research Laboratory, Estimating Water Treatment Costs, Volume 2, (August, 1979).

Environmental Science and Engineering Inc. (ESE), Technologies and Costs for Removal of Volatile Organic Chemicals from Potable Water Supplies (1984).

Adams, Q.A., and R.M. Clark, "Cost Estimates for GAC Systems", EPA, Water Engineering Research Laboratory Office of Research and Development, (May, 1985).

EPA, National Primary Drinking Water Regulations: Volatile Synthetic Organic Chemicals; Final Rule and Proposed Rule, Federal Register, 50:219, 46880-46933 (November, 1985).

Hager, D. and C. Loven, "Operating Experiences in the Containment and Purification of Ground Water at the Rocky Mountain Arsenal, (November, 1982).

APPENDIX B

**COLORADO DEPARTMENT OF HEALTH**

Richard D. Lamm
Governor

Thomas M. Vernon, M.D.
Executive Director

March 11, 1986

Mr. William A. Tolle
James M. Montgomery, Consulting Engineers, Inc.
12200 East Iliff Avenue, Suite 1080
Aurora, CO 80014

Dear Mr. Tolle:

This is in response to your letter of February 4, 1986 and to verify the State's requirements for proper treatment of the South Adams County Water and Sanitation District's (SACWSD) water supply. The treatment of the SACWSD water supply will meet the following objectives:

1. The water will meet promulgated State and Federal drinking water maximum contaminant levels (MCL's) in effect in January 1986.
2. The water will meet the MCL's for volatile organic chemicals (VOC's) proposed by EPA in the November 13, 1985 Federal Register.
3. The District will attempt to meet the proposed RMCL's for synthetic organic chemicals (SOC's), and inorganic chemicals.
4. The District will provide treatment to reduce concentrations of Arsenal - unique compounds.
5. The District will meet all other MCL's for organic, inorganic, microbiological, and radiological contaminants.
6. The District will meet to submit plans and specifications for the treatment system to CDH for our review and approval prior to construction.

7. If air stripping is to be proposed for treatment, you will need to contact the Air Pollution Control Division to obtain an Air Emissions Permit.

Thank you for your co-operation. Please call if you have any questions.

Sincerely,



Richard J. Karlin, P.E.
Section Chief
Drinking Water/Ground Water Section
Water Quality Control Division

RJK:MJG/ras

xc: Larry Ford
Richard Dehncke
John Blair
Mary Gearhart
SACWSD file

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1.7.1.1

JAMES M. MONTGOMERY, CONSULTING ENGINEERS, INC.

12200 East Iliff Avenue, Suite 108, Aurora, Colorado 80014/(303) 695-4030

February 4, 1986

Ms. Mary J. Gearhart
Public Health Engineer
Colorado Department of Health
Water Quality Control Division
4210 East 11th Avenue
Denver, CO 80220

Dear Mary:

We are sending this letter to confirm in writing what we understand to be the requirements for treated drinking water quality for the South Adams County Water and Sanitation District. The program described below is in accord with the District's meeting with the Colorado Department of Health and the Environmental Protection Agency January 14, 1986 and our subsequent clarification with you the following day. The components of the requirements for facilities currently under study are as follows:

1. The District will meet promulgated State and Federal drinking water maximum contaminant levels (MCL's) in effect in January 1986.
2. The District will comply with proposed MCL's for volatile organic chemicals (VOC's) as described by EPA in the November 13, 1985 Federal Register, summarized on page 46904, Table 2.
3. The District will follow with the Department of Health Services and the EPA the progress of EPA's November 13, 1985 proposed rules for synthetic organic chemicals (SOC's), inorganic chemicals and microorganisms. At the time of this study, RMCL's have been proposed, but no proposed MCL's have been issued. The current District study will aim at providing water quality as close to the proposed RMCL's as possible, taking cost into consideration.
4. For the unique organic chemicals applicable to contamination control at Rocky Mountain Arsenal but not covered by current EPA proposals for MCL's or RMCL's, the District will provide granular activated carbon treatment or other treatment suitable to reduce concentrations of these compounds.

We appreciate your efforts to resolve the treated water quality requirements as soon as possible so the District can proceed with its efforts to treat its groundwater supply. If your understanding of the above goals is for any reason not in accord with the above, we would appreciate your response in writing by February 10, 1986.

Very truly yours,

William A. Tolle

William A. Tolle
Vice President

/rdb

bcc: Larry Ford/Carol Tate

APPENDIX C

**ORGANICS WATER
QUALITY DATA**

CENREF LABORATORY REPORT

EPA Method 624

Cenref Lab No. C85MS-240 Date Sampled November 5, 1985
 Sampled by FKF Date Received November 5, 1985
 Requested by Jeff Foster Date Completed November 22, 1985
 Sample Description: SA-DW-05-1185 @ 15:59

VOLATILE ORGANICS:	CAS No.:	RESULT: ($\mu\text{g/l}$) ¹	AMD L: ($\mu\text{g/l}$) ²	SDL: ($\mu\text{g/l}$) ³
Chloromethane	74-87-3	BDL	5	
Bromomethane	74-83-9	BDL	5	
Vinyl Chloride	75-01-4	BDL	5	
Chloroethane	75-00-3	BDL	5	
Methylene Chloride	75-09-2	BDL	1	
1,1-Dichloroethene	75-35-4	EDL	1	
1,1-Dichloroethane	75-34-3	EDL	1	
Trans-1,2-Dichloroethene	156-60-5	EDL	2	
Chloroform	67-66-3	BDL	1	
1,2-Dichloroethane	107-06-2	BDL	1	
1,1,1-Trichloroethane	71-55-6	BDL	1	
Carbon Tetrachloride	56-23-5	BDL	1	
Bromodichloromethane	75-27-4	BDL	1	
1,2-Dichloropropane	78-87-5	BDL	1	
Trans-1,3-Dichloropropene	10061-02-6	EDL	1	
Trichloroethene	79-01-6	11	1	
Dibromochloromethane	124-48-1	BDL	1	
1,1,2-Trichloroethane	79-00-5	EDL	1	
Benzene	71-43-2	BDL	1	
cis-1,3-Dichloropropene	10061-01-5	BDL	1	
2-Chloroethylvinylether	110-75-8	BDL	5	
Bromoform	75-25-2	14	1	
Tetrachloroethene	127-18-4	4	1	
1,1,2,2-Tetrachloroethane	79-34-5	BDL	1	
Toluene	108-88-3	EDL	1	
Chlorobenzene	108-90-7	EDL	1	
Ethylbenzene	100-41-4	EDL	1	

¹BDL = "Below Detection Limit" (SDL)

²Approximate Method Detection Limit

³Sample Detection Limit (if different than AMDL)

Comments: _____

cc: HRS-L
CRC-2
SADMS-L

R. G. Stites

General Manager
Title

Invoice: HRS Water Consultants, Inc., 1350 Independence Street, Suite 3-A,
Lakewood, Colorado 80215

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141

Mid-Continent Area: R.R. 2, Box 119, Liberal, Kansas 67901 • (316) 624-4292

Rocky Mountain Area: P.O. Box 68, Brighton, Colorado 80601 • (303) 659-0497

CENREF LABORATORY REPORT

EPA Method 624

Cenref Lab No. C85MS-239 Date Sampled November 5, 1985
 Sampled by JSF Date Received November 5, 1985
 Requested by Jeff Foster Date Completed November 22, 1985
 Sample Description: SA-DW-14-1185 @ 15:40

VOLATILE ORGANICS:	CAS No.:	RESULT: (µg/l) ¹	AMD L: (µg/l) ²	SDL: (µg/l) ³
Chloromethane	74-87-3	BDL	5	
Bromomethane	74-83-9	BDL	5	
Vinyl Chloride	75-01-4	BDL	5	
Chloroethane	75-00-3	BDL	5	
Methylene Chloride	75-09-2	BDL	1	
1,1-Dichloroethene	75-35-4	BDL	1	
1,1-Dichloroethane	75-34-3	BDL	1	
Trans-1,2-Dichloroethene	156-60-5	BDL	2	
Chloroform	67-66-3	BDL	1	
1,2-Dichloroethane	107-06-2	BDL	1	
1,1,1-Trichloroethane	71-55-6	BDL	1	
Carbon Tetrachloride	56-23-5	BDL	1	
Bromodichloromethane	75-27-4	BDL	1	
1,2-Dichloropropane	78-87-5	BDL	1	
Trans-1,3-Dichloropropene	10061-02-6	BDL	1	
Trichloroethene	79-01-6	8	1	
Dibromochloromethane	124-48-1	BDL	1	
1,1,2-Trichloroethane	79-00-5	BDL	1	
Benzene	71-43-2	BDL	1	
cis-1,3-Dichloropropene	10061-01-5	BDL	1	
2-Chloroethylvinylether	110-75-8	BDL	5	
Bromoform	75-25-2	BDL	1	
Tetrachloroethene	127-18-4	2	1	
1,1,2,2-Tetrachloroethane	79-34-5	BDL	1	
Toluene	108-88-3	BDL	1	
Chlorobenzene	108-90-7	BDL	1	
Ethylbenzene	100-41-4	BDL	1	

¹BDL = "Below Detection Limit" (SDL)

²Approximate Method Detection Limit

³Sample Detection Limit (if different than AMDL.)

Comments:

cc: HRS-L
CRC-2
SADMS-L

R.C. Zites

General Manager
Title

Invoice: HRS Water Consultants, Inc., 1350 Independence Street, Suite 3-A,
Lakewood, Colorado 80215

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141

Mid-Continent Area: R.R. 2, Box 119, Liberal, Kansas 67901 • (316) 624-4292

Rocky Mountain Area: P.O. Box 68, Brighton, Colorado 80601 • (303) 659-0497

CENREF LABORATORY REPORT

EPA Method 624

Cenref Lab No. C85MS-230 Date Sampled November 5, 1985
 Sampled by JSF Date Received November 5, 1985
 Requested by Jeff Foster Date Completed November 22, 1985
 Sample Description: SA-DW-15-1185 @ 11:26

VOLATILE ORGANICS:	CAS No.:	RESULT: (µg/l) ¹	AMDL: (µg/l) ²	SDL: (µg/l) ³
Chloromethane	74-87-3	BDL	5	
Bromomethane	74-83-9	BDL	5	
Vinyl Chloride	75-01-4	BDL	5	
Chloroethane	75-00-3	BDL	5	
Methylene Chloride	75-09-2	BDL	1	
1,1-Dichloroethene	75-35-4	BDL	1	
1,1-Dichloroethane	75-34-3	3	1	
Trans-1,2-Dichloroethene	156-60-5	BDL	2	
Chloroform	67-66-3	BDL	1	
1,2-Dichloroethane	107-06-2	BDL	1	
1,1,1-Trichloroethane	71-55-6	1	1	
Carbon Tetrachloride	56-23-5	BDL	1	
Bromodichloromethane	75-27-4	BDL	1	
1,2-Dichloropropane	78-87-5	BDL	1	
Trans-1,3-Dichloropropene	10061-02-6	BDL	1	
Trichloroethene	79-01-6	2	1	
Dibromochloromethane	124-48-1	BDL	1	
1,1,2-Trichloroethane	79-00-5	BDL	1	
Benzene	71-43-2	BDL	1	
cis-1,3-Dichloropropene	10061-01-5	BDL	1	
2-Chloroethylvinylether	110-75-8	BDL	5	
Bromoform	75-25-2	BDL	1	
Tetrachloroethene	127-18-4	2	1	
1,1,2,2-Tetrachloroethane	79-34-5	BDL	1	
Toluene	108-88-3	BDL	1	
Chlorobenzene	108-90-7	BDL	1	
Ethylbenzene	100-41-4	BDL	1	

¹BDL = "Below Detection Limit" (SDL)

²Approximate Method Detection Limit

³Sample Detection Limit (if different than AMDL)

Comments:

cc: HRS-L
 CRC-2
 SADMS-L

R.E. Zites

General Manager
 Title

Invoice: HRS Water Consultants, Inc., 1350 Independence Street, Suite 3-A,
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Rocky Mountain Area: P.O. Box 68, Brighton, Colorado 80601 • (303) 659-0497

CENREF LABORATORY REPORT

EPA Method 624

Cenref Lab No. C85MS-236 Date Sampled November 5, 1985
 Sampled by ISF Date Received November 5, 1985
 Requested by Jeff Foster Date Completed November 22, 1985
 Sample Description: SA-DW-16-1185 @ 13:40

VOLATILE ORGANICS:	CAS No.:	RESULT: (µg/l) ¹	AMDL: (µg/l) ²	SDL: (µg/l) ³
Chloromethane	74-87-3	BDL	5	
Bromomethane	74-83-9	BDL	5	
Vinyl Chloride	75-01-4	BDL	5	
Chloroethane	75-00-3	BDL	5	
Methylene Chloride	75-09-2	BDL	1	
1,1-Dichloroethene	75-35-4	BDL	1	
1,1-Dichloroethane	75-34-3	BDL	1	
Trans-1,2-Dichloroethene	156-60-5	BDL	2	
Chloroform	67-66-3	BDL	1	
1,2-Dichloroethane	107-06-2	BDL	1	
1,1,1-Trichloroethane	71-55-6	5	1	
Carbon Tetrachloride	56-23-5	BDL	1	
Bromodichloromethane	75-27-4	BDL	1	
1,2-Dichloropropane	78-87-5	BDL	1	
Trans-1,3-Dichloropropene	10061-02-6	BDL	1	
Trichloroethene	79-01-6	15	1	
Dibromochloromethane	124-48-1	BDL	1	
1,1,2-Trichloroethane	79-00-5	BDL	1	
Benzene	71-43-2	BDL	1	
cis-1,3-Dichloropropene	10061-01-5	BDL	1	
2-Chloroethylvinylether	110-75-8	BDL	5	
Bromoform	75-25-2	BDL	1	
Tetrachloroethene	127-18-4	8	1	
1,1,2,2-Tetrachloroethane	79-34-5	BDL	1	
Toluene	108-88-3	BDL	1	
Chlorobenzene	108-90-7	BDL	1	
Ethylbenzene	100-41-4	BDL	1	

¹BDL = "Below Detection Limit" (SDL)

²Approximate Method Detection Limit

³Sample Detection Limit (if different than AMDL)

Comments:

cc: HRS-L
CRC-2
SADMS-L

R. E. Stites

General Manager
Title

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CENREF LABORATORY REPORT

EPA Method 624

Cenref Lab No. C85MS-238 Date Sampled November 5, 1985
 Sampled by JSF Date Received November 5, 1985
 Requested by Jeff Foster Date Completed November 22, 1985
 Sample Description: SA-DW-17-1185 @ 14:34

VOLATILE ORGANICS:	CAS No.:	RESULT: ($\mu\text{g/l}$) ¹	AMDL: ($\mu\text{g/l}$) ²	SDL: ($\mu\text{g/l}$) ³
Chloromethane	74-87-3	BDL	5	
Bromomethane	74-83-9	BDL	5	
Vinyl Chloride	75-01-4	BDL	5	
Chloroethane	75-00-3	BDL	5	
Methylene Chloride	75-09-2	BDL	1	
1,1-Dichloroethene	75-35-4	BDL	1	
1,1-Dichloroethane	75-34-3	BDL	1	
Trans-1,2-Dichloroethene	156-60-5	BDL	2	
Chloroform	67-66-3	BDL	1	
1,2-Dichloroethane	107-06-2	BDL	1	
1,1,1-Trichloroethane	71-55-6	4	1	
Carbon Tetrachloride	56-23-5	BDL	1	
Bromodichloromethane	75-27-4	BDL	1	
1,2-Dichloropropane	78-87-5	BDL	1	
Trans-1,3-Dichloropropene	10061-02-6	BDL	1	
Trichloroethene	79-01-6	10	1	
Dibromochloromethane	124-48-1	BDL	1	
1,1,2-Trichloroethane	79-00-5	BDL	1	
Benzene	71-43-2	BDL	1	
cis-1,3-Dichloropropene	10061-01-5	BDL	1	
2-Chloroethylvinylether	110-75-8	BDL	5	
Bromoform	75-25-2	BDL	1	
Tetrachloroethene	127-18-4	1	1	
1,1,2,2-Tetrachloroethane	79-34-5	BDL	1	
Toluene	108-88-3	BDL	1	
Chlorobenzene	108-90-7	BDL	1	
Ethylbenzene	100-41-4	BDL	1	

¹BDL = "Below Detection Limit" (SDL)

²Approximate Method Detection Limit

³Sample Detection Limit (if different than AMDL)

Comments: _____

cc: HRS-L
CRC-2
SADMS-L

R.E. Stiles

General Manager
Title

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Lakewood, Colorado 80215

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141

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CENREF LABORATORY REPORT

EPA Method 624

Cenref Lab No. C85MS-229 Date Sampled November 5, 1985
 Sampled by ISF Date Received November 5, 1985
 Requested by Jeff Foster Date Completed November 22, 1985
 Sample Description: SA-DW-18-1185 @ 11:05

VOLATILE ORGANICS:	CAS No.:	RESULT: (µg/l) ¹	AMDL: (µg/l) ²	SDL: (µg/l) ³
Chloromethane	74-87-3	BDL	5	
Bromomethane	74-83-9	BDL	5	
Vinyl Chloride	75-01-4	BDL	5	
Chloroethane	75-00-3	BDL	5	
Methylene Chloride	75-09-2	BDL	1	
1,1-Dichloroethene	75-35-4	EDL	1	
1,1-Dichloroethane	75-34-3	BDL	1	
Trans-1,2-Dichloroethene	156-60-5	EDL	2	
Chloroform	67-66-3	BDL	1	
1,2-Dichloroethane	107-06-2	BDL	1	
1,1,1-Trichloroethane	71-55-6	1	1	
Carbon Tetrachloride	56-23-5	BDL	1	
Bromodichloromethane	75-27-4	BDL	1	
1,2-Dichloropropane	78-87-5	BDL	1	
Trans-1,3-Dichloropropene	10061-02-6	EDL	1	
Trichloroethene	79-01-6	BDL	1	
Dibromochloromethane	124-48-1	BDL	1	
1,1,2-Trichloroethane	79-00-5	BDL	1	
Benzene	71-43-2	BDL	1	
cis-1,3-Dichloropropene	10061-01-5	BDL	1	
2-Chloroethylvinylether	110-75-8	BDL	5	
Bromoform	75-25-2	BDL	1	
Tetrachloroethene	127-18-4	1	1	
1,1,2,2-Tetrachloroethane	79-34-5	2	1	
Toluene	108-88-3	BDL	1	
Chlorobenzene	108-90-7	BDL	1	
Ethylbenzene	100-41-4	BDL	1	

¹BDL = "Below Detection Limit" (SDL)

²Approximate Method Detection Limit

³Sample Detection Limit (if different than AMDL)

Comments:

cc: HRS-L
CRC-2
SADMS-L

R.E. Stites

General Manager
Title

Invoice: HRS Water Consultants, Inc., 1350 Independence Street, Suite 3-A,
Lakewood, Colorado 80215

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141

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Rocky Mountain Area: P.O. Box 68, Brighton, Colorado 80601 • (303) 659-0497

Cenref Labs

Century Refining Company

CENREF LABORATORY REPORT

Cenref Laboratory No. See below.

Date Submitted November 5, 1985

Requested By Jeff Foster

Date Completed November 13, 1985

Sample Identification	Analysis	Result
SA-MW-03-1185 @ 13:35	DBCP	less than 0.06 $\mu\text{g}/\text{l}$
(C85P-1565)		
SA-MW-11-1185 @ 14:10	DBCP	less than 0.06 $\mu\text{g}/\text{l}$
(C85P-1566)		
SA-MW-04-1185 @ 14:50	DBCP	less than 0.06 $\mu\text{g}/\text{l}$
(C85P-1567)		
SA-MW-08-1185 @ 15:35	DBCP	less than 0.06 $\mu\text{g}/\text{l}$
(C85P-1568)		
SA-MW-09-1185 @ 16:21	DBCP	less than 0.06 $\mu\text{g}/\text{l}$
(C85P-1569)		
SA-MW-06-1185 @ 16:56	DBCP	less than 0.06 $\mu\text{g}/\text{l}$
(C85P-1570)		
SA-MW-05-1185 @ 17:30	DBCP	less than 0.06 $\mu\text{g}/\text{l}$
(C85P-1571)		

cc: HRS(L)
CRC-2
SA-L

R. Q. Stites

General Manager
Title

Invoice: HRS Water Consultants, Inc.

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141

Mid-Continent Area: R.R. 2, Box 119, Liberal, Kansas 67901 • (316) 624-4292

Rocky Mountain Area: P.O. Box 68, Brighton, Colorado 80601 • (303) 659-0497

Cenref Labs

Century Refining Company

CENREF LABORATORY REPORT

Cenref Laboratory No. See below. Date Submitted November 5, 1985

Requested By Jeff Foster Date Completed November 13, 1985

Sample Identification	Analysis	Result
SA-DW-16-1185 @ 13:40 (C85P-1558)	DBCP	less than 0.06 μ g/l
SA-BL-01-1185 @ 14:00 (C85P-1559)	DBCP	less than 0.06 μ g/l
SA-DW-17-1185 @ 14:34 (C85P-1560)	DBCP	less than 0.06 μ g/l
SA-DW-14-1185 @ 15:40 (C85P-1561)	DBCP	less than 0.06 μ g/l
SA-DW-05-1185 @ 15:59 (C85P-1562)	DBCP	less than 0.06 μ g/l
SA-MW-01-1185 @ 12:20 (C85P-1563)	DBCP	less than 0.06 μ g/l
SA-MW-02-1185 @ 12:55 (C85P-1564)	DBCP	less than 0.06 μ g/l

cc: HRS(L)
CRC-2
SA-L

R. E. Zittes

General Manager
Title

Invoice: HRS Water Consultants, Inc.

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141
Mid-Continent Area: R.R. 2, Box 119, Liberal, Kansas 67901 • (316) 624-4292
Rocky Mountain Area: P.O. Box 68, Brighton, Colorado 80601 • (303) 659-0497

ANALYTICAL RESULTS REPORT
SOUTH ADAMS COUNTY WATER AND
SANITATION DISTRICT

TDD R8-8503-16

EPA REGIONAL PROJECT OFFICER - WALTER SANDZA

E&E PROJECT OFFICER - KARL FORD

SUBMITTED TO: KEITH SCHWAB, FIT-RPO
WILLIAM GEISE, REM-FIT COORDINATOR

DATE SUBMITTED: MAY 14, 1985

TABLE 1A: SAMPLE DESIGNATION AND LOCATIONS, SACWSD

<u>Sample Designation</u>	<u>Address</u>
SA-SAC-2	77th and Pontiac
SA-SAC-4	77th and Pontiac
SA-SAC-8	7201 E 64th Ave.
SA-SAC-9	6595 E. 70th Ave.
SA-SAC-11	64th and Colorado
SA-SAC-12	64th and Colorado
SA-SAC-13A	56th and Niagara
SA-SAC-13B	56th and Niagara
SA-SAC-14	7201 E. 64th Ave.
SA-SAC-16	6595 E. 70th Ave.
SA-SAC-17	77th and Quebec
SA-SAC-18	64th and Quebec
SA-DW-1A	4301 E. 72nd Ave.
SA-DW-1B	4301 E. 72nd Ave.
SA-DW-2	5181 E. 56th Ave.
SA-DW-3	7111 E. 56th Ave.
SA-DW-4	6500 E. 72nd Ave.

TABLE 1B: PRIVATE WELL SAMPLE DESIGNATIONS AND LOCATIONS

<u>Sample Designation</u>	<u>Address</u>
SA-PWS-3	5181 E. 56th Ave.
SA-PWS-5	6195 Ivy St.
SA-OP-5	7130 E. 72nd Pl.
SA-OP-6	4080 E. 70th
SA-OP-7	6081 E. 67th Pl.
SA-OP-16	5286 Newport
SA-PWS-1*	7020 E. 53rd Way
SA-PWS-2*	6411 E. 53rd Way
SA-PWS-4*	3796 E. 64th Ave.

* Unable to sample during January, 1985. May, 1984 data were used for contour maps.

TABLE 2 ORGANOANALYTICAL RESULTS. ($\mu\text{g/l}$), SOUTH ADAMS COUNTY, COLORADO[illegible]

- detected compounds only

3. Indication not linked concentration butatively identified at less than contract required detection limits or not in total conformance with quality assurance criteria.

TABLE 3

LIST OF ORGANIC CONTAMINANTS MONITORED

VOLATILES

acrolein
acrylonitrile
benzene
carbon tetrachloride
chlorobenzene
1,2-dichloroethane
1,1,1-trichloroethane
1,1-dichloroethane
1,1,2-trichloroethane
1,1,2,2-tetrachloroethane
chloroethane
2-chloroethylvinyl ether
chloroform
1,1-dichloroethene
trans-1,2-dichloroethene
1,2-dichloropropane
trans-1,3-dichloropropane
cis-1,3-dichloropropane
ethylbenzene
methylene chloride
chloromethane
bromomethane
bromoforn
bromodichloromethane
fluorotrichloromethane
dichlorodifluoromethane
chlorodibromomethane
tetrachloroethane
toluene
trichloroethene
vinyl chloride
acetone
2-butanone
carbonyl sulfide
2-hexanone
4-methyl-2-pentanone
styrene
vinyl acetate
total xylenes
2-PENTANONE

PESTICIDES

aldrin
dieldrin
chlordane
γ-DDT
γ-DDD
γ-DDD
α-endosulfan
β-endosulfan
endosulfan sulfate
endrin
endrin aldehyde
heptachlor
heptachlor epoxide
α-BHC
β-BHC
δ-BHC
γ-BHC (lindane)
PCB-1262
PCB-1254
PCB-1221
PCB-1272
PCB-1248
PCB-1260
PCB-1816
toxaphene

SEMI-VOLATILES

2,4,6-trichlorophenol
p-chloro-m-cresol
2-chlorophenol
2,6-dichlorophenol
2,6-dimethylphenol
2-nitrophenol
4-nitrophenol
2,4-dinitrophenol
2,6-dinitro-2-methylphenol
pentachlorophenol
phenol
benzoic acid
2-methylphenol
4-methylphenol
2,4,5-trichlorophenol
acenaphthene
benzidine
1,2,4-trichlorobenzene
hexachlorobenzene
hexachloroethane
bis(2-chloroethyl) ether
2-chloronaphthalene
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
3,5-dichlorobenzidine
2,4-dinitrotoluene
2,6-dinitrotoluene
1,2-diphenylhydrazine
fluoranthene
4-chlorophenyl phenyl ether
4-bromophenyl phenyl ether
bis (2-chloroisopropyl) ether
bis (2-chloroethoxy) methane
hexachlorobutadiene
hexachlorocyclopentadiene
isophenone
naphthalene
nitrobenzene
N-nitrosodimethylamine
N-nitrosodiphenylamine
N-nitrosopropylamine
bis (2-ethylhexyl) phthalate
benzyl butyl phthalate
di-n-butyl phthalate
di-n-octyl phthalate
diethyl phthalate
dimethyl phthalate
benzo(a)anthracene
benzo(a)pyrene
benzo(b)fluoranthene
benzo(k)fluoranthene
chrysene
acenaphthylene
anthracene
benzo(g,h,i)perylene
fluorene
phenanthrene
dibenz(a,h)anthracene
indeno(1,2,3-cd)pyrene
pyrene
aniline
benzyl alcohol
4-chloroaniline
dibenzofuran
2-methylnaphthalene
2-nitroaniline
3-nitroaniline
4-nitroaniline

TABLE 4
LIST OF SAS ORGANIC COMPOUNDS, SACWSD SAMPLING.

Diisopropylmethyl phosphonate

Dimethylmethyl phosphonate

Dicyclopentadiene

Dibromochloropropane

Diathiane

Oxathiane

p-chlorophenylmethyl sulfide

p-chlorophenylmethyl sulfoxide

p-chlorophenylmethyl sulfone

malathion

parathion

isodrin

ethyl parathion

methyl paration

ethylene dibromide

CENREF LABORATORY REPORT

EPA Method 624

Cenref Lab No. C85MS-233 Date Sampled November 5, 1985
 Sampled by FKW Date Received November 5, 1985
 Requested by Jeff Foster Date Completed November 22, 1985
 Sample Description: SA-DW-02-1185 @ 11:58

VOLATILE ORGANICS:	CAS No.:	RESULT: ($\mu\text{g/l}$) ¹	AMDL: ($\mu\text{g/l}$) ²	SDL: ($\mu\text{g/l}$) ³
Chloromethane	74-87-3	BDL	5	
Bromomethane	74-83-9	BDL	5	
Vinyl Chloride	75-01-4	BDL	5	
Chloroethane	75-00-3	BDL	5	
Methylene Chloride	75-09-2	BDL	1	
1,1-Dichloroethene	75-35-4	BDL	1	
1,1-Dichloroethane	75-34-3	6	1	
Trans-1,2-Dichloroethene	156-60-5	BDL	2	
Chloroform	67-66-3	BDL	1	
1,2-Dichloroethane	107-06-2	BDL	1	
1,1,1-Trichloroethane	71-55-6	7	1	
Carbon Tetrachloride	56-23-5	BDL	1	
Bromodichloromethane	75-27-4	BDL	1	
1,2-Dichloropropane	78-87-5	BDL	1	
Trans-1,3-Dichloropropene	10061-02-6	BDL	1	
Trichloroethene	79-01-6	19	1	
Dibromochloromethane	124-48-1	BDL	1	
1,1,2-Trichloroethane	79-00-5	BDL	1	
Benzene	71-43-2	BDL	1	
cis-1,3-Dichloropropene	10061-01-5	BDL	1	
2-Chloroethylvinylether	110-75-8	BDL	5	
Bromoform	75-25-2	BDL	1	
Tetrachloroethene	127-18-4	11	1	
1,1,2,2-Tetrachloroethane	79-34-5	BDL	1	
Toluene	108-88-3	BDL	1	
Chlorobenzene	108-90-7	BDL	1	
Ethylbenzene	100-41-4	BDL	1	

¹BDL = "Below Detection Limit" (SDL)

²Approximate Method Detection Limit

³Sample Detection Limit (if different than AMDL)

Comments: _____

cc: HRS-L
CRC-2
SADMS-L

R. Q. Stites

General Manager
Title

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Lakewood, Colorado 80215

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141

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CENREF LABORATORY REPORT

EPA Method 624

Cenref Lab No. C85MS-231

Date Sampled November 5, 1985

Sampled by ISF

Date Received November 5, 1985

Requested by Jeff Foster

Date Completed November 22, 1985

Sample Description: SA-DW-03-1185 @ 11:50

VOLATILE ORGANICS:	CAS No.:	RESULT: ($\mu\text{g/l}$) ¹	AMD L: ($\mu\text{g/l}$) ²	SDL: ($\mu\text{g/l}$) ³
Chloromethane	74-87-3	BDL	5	
Bromomethane	74-83-9	EDL	5	
Vinyl Chloride	75-01-4	BDL	5	
Chloroethane	75-00-3	BDL	5	
Methylene Chloride	75-09-2	BDL	1	
1,1-Dichloroethene	75-35-4	EDL	1	
1,1-Dichloroethane	75-34-3	BDL	1	
Trans-1,2-Dichloroethene	156-60-5	3	2	
Chloroform	67-66-3	EDL	1	
1,2-Dichloroethane	107-06-2	EDL	1	
1,1,1-Trichloroethane	71-55-6	5	1	
Carbon Tetrachloride	56-23-5	BDL	1	
Bromodichloromethane	75-27-4	BDL	1	
1,2-Dichloropropane	78-87-5	EDL	1	
Trans-1,3-Dichloropropene	10061-02-6	EDL	1	
Trichloroethene	79-01-6	46	1	
Dibromochloromethane	124-48-1	EDL	1	
1,1,2-Trichloroethane	79-00-5	BDL	1	
Benzene	71-43-2	BDL	1	
cis-1,3-Dichloropropene	10061-01-5	BDL	1	
2-Chloroethylvinylether	110-75-8	BDL	5	
Bromoform	75-25-2	BDL	1	
Tetrachloroethene	127-18-4	8	1	
1,1,2,2-Tetrachloroethane	79-34-5	BDL	1	
Toluene	108-88-3	BDL	1	
Chlorobenzene	108-90-7	EDL	1	
Ethylbenzene	100-41-4	EDL	1	

¹BDL = "Below Detection Limit" (SDL)

²Approximate Method Detection Limit

³Sample Detection Limit (if different than AMDL)

Comments:

cc: HRS-L
CRC-2
SADMS-L

R. G. Zittes

General Manager
Title

Invoice: HRS Water Consultants, Inc., 1350 Independence Street, Suite 3-A,
Lakewood, Colorado 80215

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141

Mid-Continent Area: R.R. 2, Box 119, Liberal, Kansas 67901 • (316) 624-4292

Rocky Mountain Area: P.O. Box 68, Brighton, Colorado 80601 • (303) 659-0497

Cenref Labs

Century Refining Company

CENREF LABORATORY REPORT

Cenref Laboratory No. See below.

Date Submitted November 5, 1985

Requested By Jeff Foster

Date Completed November 13, 1985

Sample Identification	Analysis	Result
SA-DW-18-1185 @ 11:05	DBCP	less than 0.06 μ g/l
(C85P-1551)		
SA-DW-15-1185 @ 11:26	DBCP	less than 0.06 μ g/l
(C85P-1552)		
SA-DW-03-1185 @ 11:50	DBCP	less than 0.06 μ g/l
(C85P-1553)		
SA-PW-01-1185 @ 11:55	DBCP	less than 0.06 μ g/l
(C85P-1554)		
SA-DW-02-1185 @ 11:58	DBCP	less than 0.06 μ g/l
(C85P-1555)		
SA-PW-02-1185 @ 12:46	DBCP	less than 0.06 μ g/l
(C85P-1556)		
SA-PW-03-1185 @ 13:05	DBCP	less than 0.06 μ g/l
(C85P-1557)		

cc: HRS(L)
CRC-2

SA-Leeper

R.E. Stites

General Manager
Title

Invoice: HRS Water Consultants, Inc., 1350 Independence Street, Suite 3-A, Lakewood, CO 80215

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141

Mid-Continent Area: R.R. 2, Box 119, Liberal, Kansas 67901 • (316) 624-4292

Rocky Mountain Area: P.O. Box 68, Brighton, Colorado 80601 • (303) 659-0497

CENREF LABORATORY REPORT

EPA Method 624

Cenref Lab No. C85MS-3192

Date Sampled _____

Sampled by DMK

Date Received December 6, 1985

Requested by Jff Foster

Date Completed December 27, 1985

Sample Description: SA-DW-02-1285, December 5, 1985, 11:03

VOLATILE ORGANICS:	CAS No.:	RESULT: ($\mu\text{g/l}$) ¹	AMD L: ($\mu\text{g/l}$) ²	SDL: ($\mu\text{g/l}$) ³
Chloromethane	74-87-3	BDL	5	
Bromomethane	74-83-9	BDL	5	
Vinyl Chloride	75-01-4	BDL	5	
Chloroethane	75-00-3	BDL	5	
Methylene Chloride	75-09-2	9	1	
1,1-Dichloroethene	75-35-4	BDL	1	
1,1-Dichloroethane	75-34-3	4	1	
Trans-1,2-Dichloroethene	156-60-5	BDL	2	
Chloroform	67-66-3	BDL	1	
1,2-Dichloroethane	107-06-2	BDL	1	
1,1,1-Trichloroethane	71-55-6	5	1	
Carbon Tetrachloride	56-23-5	BDL	1	
Bromodichloromethane	75-27-4	BDL	1	
1,2-Dichloropropane	78-87-5	BDL	1	
Trans-1,3-Dichloropropene	10061-02-6	BDL	1	
Trichloroethene	79-01-6	31	1	
Dibromochloromethane	124-48-1	BDL	1	
1,1,2-Trichloroethane	79-00-5	BDL	1	
Benzene	71-43-2	BDL	1	
cis-1,3-Dichloropropene	10061-01-5	BDL	1	
2-Chloroethylvinylether	110-75-8	BDL	5	
Bromoform	75-25-2	BDL	1	
Tetrachloroethene	127-18-4	7	1	
1,1,2,2-Tetrachloroethane	79-34-5	BDL	1	
Toluene	108-88-3	BDL	1	
Chlorobenzene	108-90-7	BDL	1	
Ethylbenzene	100-41-4	BDL	1	

¹BDL = "Below Detection Limit" (SDL)

²Approximate Method Detection Limit

³Sample Detection Limit (if different than AMDL)

Comments: _____

cc: HRS(L)
CRC-2

R. Q. Stites

General Manager
Title

Invoice: HRS Water Consultants, Inc.

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141

Mid-Continent Area: R.R. 2, Box 119, Liberal, Kansas 67901 • (316) 624-4292

Rocky Mountain Area: P.O. Box 88, Brighton, Colorado 80601 • (303) 659-0497

CENREF LABORATORY REPORT

EPA Method 624

Cenref Lab No. C85MS-3193

Date Sampled _____

Sampled by JSF

Date Received December 6, 1985

Requested by Jeff Foster

Date Completed December 27, 1985

Sample Description: SA-DW-03-1285, December 5, 1985, 11:20

VOLATILE ORGANICS:	CAS No.:	RESULT: (ug/l) ¹	AMDL: (ug/l) ²	SDL: (ug/l) ³
Chloromethane	74-87-3	BDL	5	
Bromomethane	74-83-9	BDL	5	
Vinyl Chloride	75-01-4	BDL	5	
Chloroethane	75-00-3	BDL	5	
Methylene Chloride	75-09-2	9	1	
1,1-Dichloroethene	75-35-4	BDL	1	
1,1-Dichloroethane	75-34-3	BDL	1	
Trans-1,2-Dichloroethene	156-60-5	BDL	2	
Chloroform	67-66-3	BDL	1	
1,2-Dichloroethane	107-06-2	BDL	1	
1,1,1-Trichloroethane	71-55-6	4	1	
Carbon Tetrachloride	56-23-5	BDL	1	
Bromodichloromethane	75-27-4	BDL	1	
1,2-Dichloropropane	78-87-5	BDL	1	
Trans-1,3-Dichloropropene	10061-02-6	BDL	1	
Trichloroethene	79-01-6	39	1	
Dibromochloromethane	124-48-1	BDL	1	
1,1,2-Trichloroethane	79-00-5	BDL	1	
Benzene	71-43-2	BDL	1	
cis-1,3-Dichloropropene	10061-01-5	BDL	1	
2-Chloroethylvinylether	110-75-8	BDL	5	
Bromoform	75-25-2	BDL	1	
Tetrachloroethene	127-18-4	5	1	
1,1,2,2-Tetrachloroethane	79-34-5	BDL	1	
Toluene	108-88-3	BDL	1	
Chlorobenzene	108-90-7	BDL	1	
Ethylbenzene	100-41-4	BDL	1	

¹BDL = "Below Detection Limit" (SDL)

²Approximate Method Detection Limit

³Sample Detection Limit (if different than AMDL)

Comments: _____

cc: HRS(L)
CRC-2

R. C. Stites

General Manager
Title

Invoice: HRS Water Consultants, Inc.

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141

Mid-Continent Area: R.R. 2, Box 119, Liberal, Kansas 67901 • (316) 624-4292

Rocky Mountain Area: P.O. Box 68, Brighton, Colorado 80601 • (303) 659-0497

CENREF LABORATORY REPORT

EPA Method 624

Cenref Lab No. C85MS-3189 Date Sampled December 5, 1985
 Sampled by DMK Date Received December 6, 1985
 Requested by Jeff Foster Date Completed December 27, 1985
 Sample Description: SA-DW-05-1285, December 5, 1985 at 10:08

VOLATILE ORGANICS:	CAS No.:	RESULT: (ug/l) ¹	AMD L: (ug/l) ²	SDL: (ug/l) ³
Chloromethane	74-87-3	BDL	5	
Bromomethane	74-83-9	BDL	5	
Vinyl Chloride	75-01-4	BDL	5	
Chloroethane	75-00-3	BDL	5	
Methylene Chloride	75-09-2	7	1	
1,1-Dichloroethene	75-35-4	BDL	1	
1,1-Dichloroethane	75-34-3	BDL	1	
Trans-1,2-Dichloroethene	156-60-5	BDL	2	
Chloroform	67-66-3	BDL	1	
1,2-Dichloroethane	107-06-2	BDL	1	
1,1,1-Trichloroethane	71-55-6	BDL	1	
Carbon Tetrachloride	56-23-5	BDL	1	
Bromodichloromethane	75-27-4	BDL	1	
1,2-Dichloropropane	78-87-5	BDL	1	
Trans-1,3-Dichloropropene	10061-02-6	BDL	1	
Trichloroethene	79-01-6	6	1	
Dibromochloromethane	124-48-1	BDL	1	
1,1,2-Trichloroethane	79-00-5	BDL	1	
Benzene	71-43-2	BDL	1	
cis-1,3-Dichloropropene	10061-01-5	BDL	1	
2-Chloroethylvinylether	110-75-8	BDL	5	
Bromoform	75-25-2	BDL	1	
Tetrachloroethene	127-18-4	3	1	
1,1,2,2-Tetrachloroethane	79-34-5	BDL	1	
Toluene	108-88-3	BDL	1	
Chlorobenzene	108-90-7	BDL	1	
Ethylbenzene	100-41-4	BDL	1	

¹BDL = "Below Detection Limit" (SDL)

²Approximate Method Detection Limit

³Sample Detection Limit (if different than AMDL)

Comments:

cc: HRS (L)
CRC-2

R. C. Zifles

General Manager
Title

Invoice: HRS Water Consultants, Inc.

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141

Mid-Continent Area: R.R. 2, Box 119, Liberal Kansas 67901 • (316) 624-4292

Rocky Mountain Area: P.O. Box 68, Brighton Colorado 80601 • (303) 659-0497

CENREF LABORATORY REPORT

EPA Method 624

Cenref Lab No. C85MS-3194

Date Sampled _____

Sampled by DMK

Date Received December 6, 1985

Requested by Jeff Foster

Date Completed December 27, 1985

Sample Description: SA-DW-15-1285, December 5, 1985, 11:43

VOLATILE ORGANICS:	CAS No.:	RESULT: ($\mu\text{g/l}$) ¹	AMDL: ($\mu\text{g/l}$) ²	SDL: ($\mu\text{g/l}$) ³
Chloromethane	74-87-3	BDL	5	
Bromomethane	74-83-9	BDL	5	
Vinyl Chloride	75-01-4	BDL	5	
Chloroethane	75-00-3	BDL	5	
Methylene Chloride	75-09-2	5	1	
1,1-Dichloroethene	75-35-4	BDL	1	
1,1-Dichloroethane	75-34-3	BDL	1	
Trans-1,2-Dichloroethene	156-60-5	BDL	2	
Chloroform	67-66-3	BDL	1	
1,2-Dichloroethane	107-06-2	BDL	1	
1,1,1-Trichloroethane	71-55-6	BDL	1	
Carbon Tetrachloride	56-23-5	BDL	1	
Bromodichloromethane	75-27-4	BDL	1	
1,2-Dichloropropane	78-87-5	BDL	1	
Trans-1,3-Dichloropropene	10061-02-6	BDL	1	
Trichloroethene	79-01-6	BDL	1	
Dibromochloromethane	124-48-1	BDL	1	
1,1,2-Trichloroethane	79-00-5	BDL	1	
Benzene	71-43-2	BDL	1	
cis-1,3-Dichloropropene	10061-01-5	BDL	1	
2-Chloroethylvinylether	110-75-8	BDL	5	
Bromoform	75-25-2	BDL	1	
Tetrachloroethene	127-18-4	BDL	1	
1,1,2,2-Tetrachloroethane	79-34-5	BDL	1	
Toluene	108-88-3	BDL	1	
Chlorobenzene	108-90-7	BDL	1	
Ethylbenzene	100-41-4	BDL	1	

¹BDL = "Below Detection Limit" (SDL)

²Approximate Method Detection Limit

³Sample Detection Limit (if different than AMDL)

Comments: _____

cc: HRS(L)
CRC-2

R. Q. Stites

General Manager
Title

Invoice: HRS Water Consultants, Inc.

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141

Mid-Continent Area: R.R. 2, Box 119, Liberal, Kansas 67901 • (316) 624-4292

Rocky Mountain Area: P.O. Box 68, Brighton, Colorado 80601 • (303) 659-0497

CENREF LABORATORY REPORT

EPA Method 624

Cenref Lab No. C85MS-3190

Date Sampled _____

Sampled by DMK

Date Received December 6, 1985

Requested by Jeff Foster

Date Completed December 27, 1985

Sample Description: SA-DW-17-1285, December 5, 1985, 10:25

VOLATILE ORGANICS:	CAS No.:	RESULT: ($\mu\text{g/l}$) ¹	AMDL: ($\mu\text{g/l}$) ²	SDL: ($\mu\text{g/l}$) ³
Chloromethane	74-87-3	BDL	5	
Bromomethane	74-83-9	BDL	5	
Vinyl Chloride	75-01-4	BDL	5	
Chloroethane	75-00-3	BDL	5	
Methylene Chloride	75-09-2	4	1	
1,1-Dichloroethene	75-35-4	BDL	1	
1,1-Dichloroethane	75-34-3	BDL	1	
Trans-1,2-Dichloroethene	156-60-5	BDL	2	
Chloroform	67-66-3	BDL	1	
1,2-Dichloroethane	107-06-2	BDL	1	
1,1,1-Trichloroethane	71-55-6	3	1	
Carbon Tetrachloride	56-23-5	BDL	1	
Bromodichloromethane	75-27-4	BDL	1	
1,2-Dichloropropane	78-87-5	BDL	1	
Trans-1,3-Dichloropropene	10061-02-6	BDL	1	
Trichloroethene	79-01-6	8	1	
Dibromochloromethane	124-48-1	BDL	1	
1,1,2-Trichloroethane	79-00-5	BDL	1	
Benzene	71-43-2	BDL	1	
cis-1,3-Dichloropropene	10061-01-5	BDL	1	
2-Chloroethylvinylether	110-75-8	BDL	5	
Bromoform	75-25-2	BDL	1	
Tetrachloroethene	127-18-4	BDL	1	
1,1,2,2-Tetrachloroethane	79-34-5	BDL	1	
Toluene	108-88-3	BDL	1	
Chlorobenzene	108-90-7	BDL	1	
Ethylbenzene	100-41-4	BDL	1	

¹BDL = "Below Detection Limit" (SDL)

²Approximate Method Detection Limit

³Sample Detection Limit (if different than AMDL)

Comments: _____

cc: HRS(L.
CRC-2

R. E. Stites

General Manager
Title

Invoice: HRS Water Consultants, Inc.

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141

Mid-Continent Area: R.R. 2, Box 149, Liberal, Kansas 67901 • (316) 624-4292

Rocky Mountain Area: P.O. Box 68, Brighton, Colorado 80601 • (303) 659-0497

CENREF LABORATORY REPORT

EPA Method 624

Cenref Lab No. C85MS-3191

Date Sampled _____

Sampled by JSF

Date Received December 6, 1985

Requested by Jeff Foster

Date Completed December 27, 1985

Sample Description: SA-DW-18-1285, December 5, 1985, 10:46

VOLATILE ORGANICS:	CAS No.:	RESULT: ($\mu\text{g/l}$) ¹	AMDL: ($\mu\text{g/l}$) ²	SDL: ($\mu\text{g/l}$) ³
Chloromethane	74-87-3	BDL	5	
Bromomethane	74-83-9	BDL	5	
Vinyl Chloride	75-01-4	BDL	5	
Chloroethane	75-00-3	BDL	5	
Methylene Chloride	75-09-2	11	1	
1,1-Dichloroethene	75-35-4	BDL	1	
1,1-Dichloroethane	75-34-3	BDL	1	
Trans-1,2-Dichloroethene	156-60-5	BDL	2	
Chloroform	67-66-3	BDL	1	
1,2-Dichloroethane	107-06-2	BDL	1	
1,1,1-Trichloroethane	71-55-6	BDL	1	
Carbon Tetrachloride	56-23-5	BDL	1	
Bromodichloromethane	75-27-4	BDL	1	
1,2-Dichloropropane	78-87-5	BDL	1	
Trans-1,3-Dichloropropene	10061-02-6	BDL	1	
Trichloroethene	79-01-6	2	1	
Dibromochloromethane	124-48-1	BDL	1	
1,1,2-Trichloroethane	79-00-5	BDL	1	
Benzene	71-43-2	BDL	1	
cis-1,3-Dichloropropene	10061-01-5	BDL	1	
2-Chloroethylvinylether	110-75-8	BDL	5	
Bromoform	75-25-2	BDL	1	
Tetrachloroethene	127-18-4	BDL	1	
1,1,2,2-Tetrachloroethane	79-34-5	BDL	1	
Toluene	108-88-3	2	1	
Chlorobenzene	108-90-7	BDL	1	
Ethylbenzene	100-41-4	BDL	1	

¹BDL = "Below Detection Limit" (SDL)

²Approximate Method Detection Limit

³Sample Detection Limit (if different than AMDL)

Comments: _____

cc: HRS(L)
CRC-2

R. E. Atiles

General Manager
Title

Invoice: HRS Water Consultants, Inc.

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141

Mid-Continent Area: R.R. 2, Box 118, Liberal, Kansas 67901 • (316) 624-4292

Rocky Mountain Area: P.O. Box 68, Brighton, Colorado 80601 • (303) 659-0497

CENREF LABORATORY REPORT

EPA Method 624

(Page 1 of 2)

Cenref Lab No. C86MA-664 Date Sampled February 12, 1986
 Sampled by FKW Date Received February 13, 1986
 Requested by Jeff Foster Date Completed February 17, 1986
 Sample Description: SA-DW-05-286

VOLATILE ORGANICS:	CAS NO.:	RESULT: (ug/l) ¹	AMD: (ug/l) ²	SDL: (ug/l) ³
Chloromethane	74-87-3	BDL	5	
Bromomethane	74-83-9	BDL	5	
Vinyl Chloride	75-01-4	BDL	5	
Chloroethane	75-00-3	BDL	5	
Methylene Chloride	75-09-2	*3	1	
1,1-Dichloroethene	75-35-4	BDL	1	
1,1-Dichloroethane	75-34-3	BDL	1	
Trans-1,2-Dichloroethene	156-60-5	BDL	2	
Chloroform	67-66-3	BDL	1	
1,2-Dichloroethane	107-06-2	BDL	1	
1,1,1-Trichloroethane	71-55-6	1	1	
Carbon Tetrachloride	56-23-5	BDL	1	
Bromodichloromethane	75-27-4	BDL	1	
1,2-Dichloropropane	78-87-5	BDL	1	
Trans-1,3-Dichloropropene	10061-02-6	BDL	1	
Trichloroethene	79-01-6	7	1	

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141

Mid-Continent Area: R.R. 2, Box 119, Liberal, Kansas 67901 • (316) 624-4292

Rocky Mountain Area: P.O. Box 68, Brighton, Colorado 80601 • (303) 659-0497

CENREF LABORATORY REPORT

EPA Method 624

(Page 2 of 2)

Cenref Lab No. C85MA-664

DW-5

VOLATILE ORGANICS:	CAS No.:	RESULT: (ug/l) ¹	AMD L: (ug/l) ²	SDL: (ug/l) ³
Dibromochloromethane	124-48-1	BDL	1	
1,1,2-Trichloroethane	79-00-5	BDL	1	
Benzene	71-43-2	BDL	1	
cis-1,3-Dichloropropene	10061-01-5	BDL	1	
2-Chloroethylvinylether	110-75-8	BDL	5	
Bromoform	75-25-2	BDL	1	
Tetrachloroethene	127-18-4	3	1	
1,1,2,2-Tetrachloroethane	79-34-5	BDL	1	
Toluene	108-88-3	BDL	1	
Chlorobenzene	108-90-7	BDL	1	
Ethylbenzene	100-41-4	BDL	1	

¹BDL = "Below Detection Limit" (SDL)

²Approximate Method Detection Limit

³Sample Detection (if different than AMDL)

Comments: *Also found in lab blank @ 4 ug / l.

cc: HRS(L)JF
SA(L)
CRC-2
Invoice:

W. Blanton

Lab Manager
Title

CENREF LABORATORY REPORT

Cenref Lab No. C86MA-666

Date Submitted February 13, 1986

Requested By Jeff Foster

Date Completed February 18, 1986

Sample Description: Water sample SA-DW-18-286

[illegible]

Comments: _____

cc: HRS(L)JF
SA(L)
CRC-2

Invoice:

William Blanton

Lab Manager
Title

CENREF LABORATORY REPORT

~~8-28-86~~
Cenref Lab No. C86R-669 Date Submitted February 13, 1986
Requested By Jeff Foster Date Completed February 28, 1986
Sample Description: Water SX, SA-DW-01-286

Analysis	Results
Endrin	< 0.0002 ug / l
Lindane	< 0.0001 ug / l
Methoxychlor	< 0.001 ug / l
Toxaphene	< 0.002 ug / l
2,4-D	< 0.01 ug / l
2,4,5-TP	< 0.001 ug / l

Comments: _____

cc: HRS(L)JF
SA(L)
CRC-2

William Blanton

Lab Manager
Title

Invoice:

MAR 27 1986

Cenref Labs

Century Refining Company

CENREF LABORATORY REPORTCenref Lab No. C86P-671 Date Submitted February 13, 1986Requested By Jeff Foster Date Completed February 28, 1986Sample Description: H2O SX, SA-DW-01-286

08

JSF 4/1/86

Analysis	Results
Endrin	< 0.0002 ug/ l
Lindane	< 0.0001 ug/ l
Methoxychlor	< 0.001 ug /l
Toxaphene	< 0.002 ug /l
2,4-D	< 0.01 ug /l
2,4,5-TP	< 0.001 ug/ l

Comments: _____

cc: HRS(L)JF
SA(L)
CRC-2William BlantonLab Manager
Title

Invoice:

Executive Offices: P.O. Box 1197, Kansas City, Missouri 64141
Mid-Continent Area: R.R. 2, Box 119, Liberal, Kansas 67901 • (316) 624-4292
Rocky Mountain Area: P.O. Box 68, Brighton, Colorado 80601 • (303) 659-0497

CENREF LABORATORY REPORT

Cenref Lab No. C86P-682 Date Submitted February 13, 1986
Requested By Jeff Foster Date Completed February 28, 1986
Sample Description: Water SX, SA-DW-09-286

Analysis	Results
Endrin	0.0002 $\mu\text{g} / \text{l}$
Lindane	0.0001 $\mu\text{g} / \text{l}$
Methoxychlor	0.001 $\mu\text{g} / \text{l}$
Toxaphene	0.002 $\mu\text{g} / \text{l}$
2,4-D	0.01 $\mu\text{g} / \text{l}$
2,4,5-TP	0.001 $\mu\text{g} / \text{l}$

Comments: _____

cc: HRS(L)JF
SA(L)
CRC-2

William Blanton

Lab Manager
Title

Invoice:

CENREF LABORATORY REPORT

Cenref Lab No. C86P-683 Date Submitted February 13, 1986

Requested By Jeff Foster Date Completed February 28, 1986

Sample Description: Water SX, SA-DW-12-286

Analysis	Results
Endrin	< 0.0002 $\mu\text{g}/\text{l}$
Lindane	< 0.0001 $\mu\text{g}/\text{l}$
Methoxychlor	< 0.001 $\mu\text{g}/\text{l}$
Toxaphene	< 0.002 $\mu\text{g}/\text{l}$
2,4-D	< 0.01 $\mu\text{g}/\text{l}$
2,4,5-TP	< 0.001 $\mu\text{g}/\text{l}$

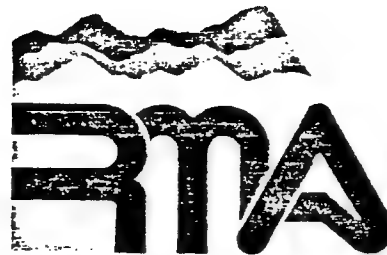
Comments: _____

cc: HRS(L)JF
SA(L)
CRC-2

William Blanton

Lab Manager
Title

Invoice:



Rocky Mountain Analytical Laboratory

May 31, 1984

Mr. Larry L. Ford, Manager
South Adams County Water and Sanitation District
6595 E. 70th Avenue
Commerce City, CO 80022

Dear Larry:

The analysis of the samples collected on May 8, 1984 from the District's existing wells is complete. Enclosed are tabulated results, discussion and methodology references. We have not attempted to interpret the results at this time. When the samples from the wells in the south and north areas are completed, I suggest that we get together to discuss the significance of the results.

Best regards,

Mark J. Carter, Ph.D.
President

MJC/tma
Enclosure

cc: David M. Brown
Harlan W. Erker, P.E.
Gary Anderson, P.E.

RMA # 3775

ANALYTICAL RESULTS

for

South Adams County Water and Sanitation District

On May 8, 1984, seventeen raw and finished water samples were collected and delivered to the laboratory. The samples are described in the attached sample description information table. The nine alluvial well water and eight bedrock well water samples were analyzed for a suite of inorganic, metal and organic parameters. Emphasis was placed on measurements at low detection limits to assess current and potential contamination.

Sampling Collection

Samples were collected by Dr. Mark Carter on May 8, 1984 with the assistance of Greg Fabisiak, Joe Stallsmith and Carl Walters from SACWSD. The wells were either in use or flushed before sampling to ensure a representative sample of the formation water. The attached well conditions table lists information about each well at the time of sampling. All samples were collected in appropriately prepared containers and preserved according to prescribed methods.

Results

Five groups of parameters are reported. They are:

- | | |
|------------------------------|-----------------|
| • Inorganic Parameters | - 14 parameters |
| • Trace Metals | - 28 elements |
| • Volatile Organics | - 31 parameters |
| • Pesticides/PCB's | - 25 parameters |
| • Grob Closed Loop Stripping | - 21 parameters |

The attached tables list the results of these analyses. Each table is arranged into alluvial and bedrock well groups for easy comparison of well water of similar origin. Results for each category are discussed below:

Inorganic Parameters

Most prominatly, the chloride, sulfate, conductivity and pH values imply independent sources for alluvial and bedrock waters. Ion balance data are also presented showing excellent agreement between the primary cations and anions listed.

Trace Metals

These data show low levels of barium, boron, iron and zinc in both alluvial and bedrock waters. Copper, selenium, vanadium, were mostly found in the alluvial wells.

Volatile Organics

The alluvial well waters contained many volatile organics. Tetrachloroethylene, 1,1,1-trichloroethane, and trichloroethylene were found in every alluvial well sample at levels up to 57 ug/L. Bromoform, chlorodibromomethane, chloroform, 1,1-dichloroethane, 1,1-dichloroethylene and 1,2-trans-dichloroethylene occurred in at least three of the alluvial well samples.

SAMPLE DESCRIPTION INFORMATION

for

South Adams County Water & Sanitation District

<u>RMA Sample No.</u>	<u>Sample Description</u>	<u>Sample Type</u>	<u>Date Sampled</u>	<u>Date Received</u>
3775-01	Well 2 77th & Pontiac	Alluvial water	5/8/84	5/8/84
3775-02	Well 3 77th & Pontiac	Alluvial water	5/8/84	5/8/84
3775-03	Well 5 77th & Quebec	Alluvial water	5/8/84	5/8/84
3775-08	Well 17 77th & Quebec	Alluvial water	5/8/84	5/8/84
3775-04	Well 14 64th & Quebec	Alluvial water	5/8/84	5/8/84
3775-06	Well 15 80th & Jasmine	Alluvial water	5/8/84	5/8/84
3775-07	Well 16 70th & Monaco	Alluvial water	5/8/84	5/8/84
3775-09	Well 18 84th & Quebec	Alluvial water	5/8/84	5/8/84
3775-05	Wells 5 & 14 After Cl ₂	Alluvial water combined	5/8/84	5/8/84
3775-12	Well 4 77th & Pontiac	Bedrock water	5/8/84	5/8/84
3775-13	Well 8 64th & Quebec	Bedrock water	5/8/84	5/8/84
3775-10	Well 1 80th & Jasmine	Bedrock water	5/8/84	5/8/84
3775-14	Well 9 70th & Monaco	Bedrock water	5/8/84	5/8/84
3775-15	Well 11 64th & Colorado	Bedrock water	5/8/84	5/8/84
3775-16	Well 12 64th & Colorado	Bedrock water	5/8/84	5/8/84
3775-17	Well 13 56th & Niagara	Bedrock water	5/8/84	5/8/84
3775-11	Well 1 After Cl ₂	Bedrock water	5/8/84	5/8/84

May 31, 1984

The bedrock wells contained few volatiles. Only benzene, bromoform and trichloroethylene were found. The highest level was 1.2 ug/l for trichloroethylene.

No other components were detected in the samples.

Interestingly, brominated haloforms dominated the treated water for wells #5 and 14 combined (3775-05). Also, wells #16 (3775-07) and #18 (3775-09) contained brominated haloforms. These two wells were reported not in use and were flushed for 10 minutes prior to sampling. The haloforms thus are difficult to explain at this time.

Pesticides/PCB's

No pesticides or PCB's were detected in any of the samples.

Grob Closed Loop Shipping Analysis

Twenty one specific chemicals were selected for analysis by CLSA as well as the identification of other prominent peaks. The volatile organic species were the major components detected. Some of the data points overlap with the volatile organics results and they support on a relative basis those results. Numerous other chemicals were detected in the samples including dichlorobenzenes and some aromatic hydrocarbons. Another chemical, bromodiodomethane was found in three samples, wells #16, #18 and the chlorinated water from wells #5 and #14 combined. The occurrence of this chemical is curious and we are performing additional analyses for iodide in these samples (to be reported later).

Methodology

Inorganic, trace metals and pesticides/PCB's were measured as described in the attached standard methodology reference lists. Volatiles and Grob Closed Loop Shipping analyses were conducted as described below:

Volatile Organics

EPA Method 524 "Measurement of Purgeable Organic Compounds in Drinking Water by Gas Chromatography/Mass Spectrometry", February 1983 was used. This sensitive method was selected to achieve detection limits around 0.2 ug/l for most volatiles of interest. Briefly, 25 ml of sample was spiked with 5.0 ug/l of internal and surrogate standards and analyzed by purge-and-trap methodology. GC/MS separation and detection was used to identify and measure the target compounds. Any additional non-target components were tentatively identified from their mass spectra and their concentrations estimated.

Grob Closed Loop Shipping Analysis (CLSA)

Each sample was also analyzed for a series of organic chemicals by CLSA. This test is 20 or more times sensitive than conventional methods for many of these chemicals. It is, however, less quantitative in nature than other specific methods. Absolute recoveries are lower than Method 524 for volatiles for example, and therefore, direct comparison of the results is not feasible, but trends and relative comparisons are. Some parameters overlap between Method 524 and CLSA but detection limits are lower for CLSA.

The CLSA method is based on research by Grob (Grob, K. "Organic Substances in Potable Water and in its Precursor, Part 1, Methods for Their Determination by Gas Chromatography", Jour. Chromatogr. 84:255 (1973)) and Coleman (Coleman, E., Melton, R., Slater, R., Kopfler, F., Voto, S., Allen, W., and Aurand, T., "Determination of Organic Contaminants by the Grob Closed Loop Stripping Technique", Journal AWWA, (73:2 (1982))). Additionally, the method has been extensively evaluated by the EPA as described in "Comparison of Grob Closed Loop Stripping Analysis (CLSA) to Other Trace Organic Methods", Advances in the Identification and Analysis of Organic Pollutants in Water, II, (L.H. Keith, ed.), Ann Arbor Sci. Pub. Inc., Ann Arbor, MI. (1981).

Briefly, one liter of sample is heated and sparged with recirculated air. The air, now containing the organics is passed over 1.5 mg of activated charcoal where the organics are adsorbed. This charcoal is then desorbed with 20 ul of carbon disulfide and an aliquot analyzed by capillary column GC/MS. Eluting components are identified by their mass spectra and quantified by their response relative to internal standards.

This technique had not been applied to the chemicals from the Rocky Mountain Arsenal until this project. The literature implied good performance for some chemicals like DCPD and DBCP and unknown behavior for DIMP and sulfur species. Our experience now indicates that DIMP and the sulfur species are not recovered well in CLSA. The detection limits are similar to those of conventional gas chromatographic methods. The advantage of CLSA is, however, that GC/MS is used to detect the components and if found the results are verified by the mass spectra.

ANALYTICAL RESULTS

for

South Adams County Water and Sanitation District

Bedrock Wells - May 8, 1984

PESTICIDES

Parameter	Units	Detection Limit	Well #4	Well #8	Well #1	Well #9	Well #11	Well #12	Well #13	Chlorinated Well #1
			3775-12	3775-13	3775-10	3775-14	3775-15	3775-16	3775-17	3775-11
1P Aldrin	ug/l	0.004	ND	ND	ND	ND	ND	ND	ND	ND
2P alpha BHC	ug/l	0.003	ND	ND	ND	ND	ND	ND	ND	ND
3P beta BHC	ug/l	0.006	ND	ND	ND	ND	ND	ND	ND	ND
4P gamma BHC	ug/l	0.004	ND	ND	ND	ND	ND	ND	ND	ND
5P delta BHC	ug/l	0.009	ND	ND	ND	ND	ND	ND	ND	ND
6P Chlordane	ug/l	0.014	ND	ND	ND	ND	ND	ND	ND	ND
7P 4,4'-DDT	ug/l	0.012	ND	ND	ND	ND	ND	ND	ND	ND
8P 4,4'-DDE	ug/l	0.004	ND	ND	ND	ND	ND	ND	ND	ND
9P 4,4'-DDD	ug/l	0.011	ND	ND	ND	ND	ND	ND	ND	ND
10P Dieldrin	ug/l	0.002	ND	ND	ND	ND	ND	ND	ND	ND
11P alpha Endosulfan	ug/l	0.014	ND	ND	ND	ND	ND	ND	ND	ND
12P beta Endosulfan	ug/l	0.004	ND	ND	ND	ND	ND	ND	ND	ND
13P Endosulfan sulfate	ug/l	0.066	ND	ND	ND	ND	ND	ND	ND	ND
14P Endrin	ug/l	0.006	ND	ND	ND	ND	ND	ND	ND	ND
15P Endrin aldehyde	ug/l	0.023	ND	ND	ND	ND	ND	ND	ND	ND
16P Heptachlor	ug/l	0.003	ND	ND	ND	ND	ND	ND	ND	ND
17P Heptachlor epoxide	ug/l	0.083	ND	ND	ND	ND	ND	ND	ND	ND
18P PCB-1016	ug/l	0.04	ND	ND	ND	ND	ND	ND	ND	ND
19P PCB-1221	ug/l	0.04	ND	ND	ND	ND	ND	ND	ND	ND
20P PCB-1232	ug/l	0.04	ND	ND	ND	ND	ND	ND	ND	ND
21P PCB-1242	ug/l	0.04	ND	ND	ND	ND	ND	ND	ND	ND
22P PCB-1248	ug/l	0.05	ND	ND	ND	ND	ND	ND	ND	ND
24P PCB-1260	ug/l	0.50	ND	ND	ND	ND	ND	ND	ND	ND
25P Toxaphene	ug/l	0.24	ND	ND	ND	ND	ND	ND	ND	ND

ND = Not detected. NR = Not requested.

ANALYTICAL RESULTS

for

South Adams County Water and Sanitation District

Bedrock Wells - May 8, 1984

VOLATILE ORGANICS

Parameter	Units	Detection Limit	Well					Chlorinated	
			#4	#8	#1	#9	#11	Well #12	Well #13
			3775-12	3775-13	3775-10	3775-14	3775-15	3775-16	3775-17
1V Acrolein	ug/l	5	ND	ND	ND	ND	ND	ND	ND
2V Acrylonitrile	ug/l	5	ND	ND	ND	ND	ND	ND	ND
3V Benzene	ug/l	0.2	ND	ND	ND	ND	ND	0.4	ND
4V Bis(chloromethyl)ether	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
5V Bromoform	ug/l	0.2	ND	0.6	ND	0.4	ND	ND	ND
6V Carbon tetrachloride	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
7V Chlorobenzene	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
8V Chlorodibromomethane	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
9V Chloroethane	ug/l	1	ND	ND	ND	ND	ND	ND	ND
10V 2-Chloroethylvinyl ether	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
11V Chloroform	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
12V Dichlorobromomethane	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
13V Dichlorodifluoromethane	ug/l	1	ND	ND	ND	ND	ND	ND	ND
14V 1,1-Dichloroethane	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
15V 1,2-Dichloroethane	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
16V 1,1,1-Dichloroethylene	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
17V 1,2-Dichloropropane	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
18V 1,3-Dichloropropylene	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
19V Ethylbenzene	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
20V Methylbromide	ug/l	1	ND	ND	ND	ND	ND	ND	ND
21V Methylchloride	ug/l	1	ND	ND	ND	ND	ND	ND	ND
22V Methylene chloride	ug/l	1	ND	ND	ND	ND	ND	ND	ND
23V 1,1,2,2-Tetrachloroethane	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
24V Tetrachloroethylene	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
25V Toluene	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
26V 1,2-trans-Dichloroethylene	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
27V 1,1,1-Trichloroethane	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
28V 1,1,2-Trichloroethane	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND
29V Trichloroethylene	ug/l	0.2	ND	0.4	ND	1.2	ND	ND	ND
30V Trichlorofluoromethane	ug/l	1	ND	ND	ND	ND	ND	ND	ND
31V Vinyl chloride	ug/l	1	ND	ND	ND	ND	ND	ND	ND

ND = Not detected. NR = Not requested.

ANALYTICAL RESULTS

for

South Adams County Water and Sanitation District

Bedrock Wells - May 8, 1984

GROB CLOSED LOOP STRIPPING - TARGET COMPOUNDS

Parameter	Units	Detection Limit	Well					Chlorinated Well		
			#4	#8	#1	#9	#11	#12	#13	#1
			3775-12	3775-13	3775-10	3775-14	3775-15	3775-16	3775-17	3775-11
benzene	ug/l	0.010	ND	ND	ND	ND	ND	ND	ND	ND
bromoform	ug/l	0.010	ND	0.39	ND	0.76	ND	ND	ND	0.26
chlorobenzene	ug/l	0.010	ND	ND	ND	ND	ND	ND	ND	ND
chlorodibromomethane	ug/l	0.010	ND	0.011	ND	0.090	ND	ND	ND	0.086
chloroform	ug/l	0.010	ND	ND	ND	0.021	ND	ND	ND	0.016
tetrachloroethylene	ug/l	0.010	0.037	0.24	0.030	0.26	0.012	0.011	0.012	0.033
toluene	ug/l	0.010	0.75	0.47	1.4	0.48	0.37	0.33	0.38	1.4
1,1,1-trichloroethane	ug/l	0.010	ND	0.16	ND	1.5	0.081	0.084	0.14	0.32
trichloroethylene	ug/l	0.010	0.037	0.23	0.021	1.8	ND	0.011	ND	0.073
total xylenes	ug/l	0.010	0.051	0.053	0.093	0.026	0.022	0.027	0.20	0.097
thioxane	ug/l	2	ND	ND	ND	ND	ND	ND	ND	ND
dithiane	ug/l	2	ND	ND	ND	ND	ND	ND	ND	ND
DCPD	ug/l	0.05	ND	ND	ND	ND	ND	ND	ND	ND
DIMP	ug/l	10	ND	ND	ND	ND	ND	ND	ND	ND
DBCP	ug/l	0.05	ND	ND	ND	ND	ND	ND	ND	ND
p-chlorophenylmethylsulfide	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND	ND
p-chlorophenylmethylsulfone	ug/l	10	ND	ND	ND	ND	ND	ND	ND	ND
p-chlorophenylmethylsulfoxide	ug/l	10	ND	ND	ND	ND	ND	ND	ND	ND
aldrin	ug/l	0.05	ND	ND	ND	ND	ND	ND	ND	ND
dieldrin	ug/l	0.05	ND	ND	ND	ND	ND	ND	ND	ND
endrin	ug/l	0.05	ND	ND	ND	ND	ND	ND	ND	ND

ND = Not detected. NR = Not requested.

South Adams County Water and Sanitation District

Alluvial Wells - May 8, 1984

VOLATILE ORGANICS

[illegible]

ANALYTICAL RESULTS

for

South Adams County Water and Sanitation District

Alluvial Wells - May 8, 1984

GROB CLOSED LOOP STRIPPING - TARGET COMPOUNDS

Parameter	Units	Detection Limit	Well #2	Well #3	Well #5	Well #17	Well #14	Well #15	Well #16	Well #18	Chlorinated Well #5/14
			3775-01	3775-02	3775-03	3775-08	3775-04	3775-06	3775-07	3775-09	
benzene	ug/l	0.010	ND	ND	ND	ND	ND	ND	ND	ND	ND
bromoform	ug/l	0.010	0.032	0.065	ND	ND	0.042	ND	1.9	4.8	0.77
chlorobenzene	ug/l	0.010	ND	ND	ND	ND	0.016	ND	0.024	0.010	ND
chlorodibromomethane	ug/l	0.010	ND	ND	ND	ND	ND	ND	0.23	0.71	0.042
chloroform	ug/l	0.010	ND	ND	ND	ND	ND	ND	0.040	0.080	0.010
tetrachloroethylene	ug/l	0.010	0.35	2.4	1.7	0.78	1.9	1.6	4.2	1.2	1.3
toluene	ug/l	0.010	ND	ND	ND	2.2	ND	ND	0.64	2.0	ND
1,1,1-trichloroethane	ug/l	0.010	0.89	1.1	0.47	0.15	0.42	0.15	0.69	ND	0.46
trichloroethylene	ug/l	0.010	0.96	1.4	0.91	1.5	10	0.58	3.9	1.9	2.9
total xylenes	ug/l	0.010	0.049	0.055	0.038	0.11	0.024	0.026	0.078	0.13	0.22
thioxane	ug/l	2	ND	ND	ND	ND	ND	ND	ND	ND	ND
dithiane	ug/l	2	ND	ND	ND	ND	ND	ND	ND	ND	ND
DCPD	ug/l	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND
DIMP	ug/l	10	ND	ND	ND	ND	ND	ND	ND	ND	ND
DBCP	ug/l	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND
p-chlorophenylmethylsulfide	ug/l	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
p-chlorophenylmethylsulfone	ug/l	10	ND	ND	ND	ND	ND	ND	ND	ND	ND
p-chlorophenylmethylsulfoxide	ug/l	10	ND	ND	ND	ND	ND	ND	ND	ND	ND
aldrin	ug/l	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND
dieldrin	ug/l	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND
endrin	ug/l	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = Not detected. NR = Not requested.

ANALYTICAL RESULTS

for

South Adams County Water and Sanitation DistrictAlluvial Wells - May 8, 1984

GROB CLOSED LOOP STRIPPING - TENTATIVE IDENTIFIED COMPOUNDS

Parameter	Units	Detection Limit	Well					Chlorinated				
			#2 3775-01	#3 3775-02	#5 3775-03	#17 3775-08	#14 3775-04	#15 3775-06	#16 3775-07	#18 3775-09	#5/14 3775-05	
Dichlorobenzene	ug/l	0.010	0.010	0.010	0.013	ND	0.20	ND	0.096	0.013	0.054	
Trichlorobenzene	ug/l	0.010	ND	ND	0.010	ND	0.011	ND	ND	ND	ND	
Propylbenzene	ug/l	0.010	ND	ND	ND	ND	0.028	ND	ND	ND	ND	
C ₄ -Benzene	ug/l	0.010	ND	ND	ND	ND	0.015	ND	ND	ND	ND	
Thiophene	ug/l	0.025	ND	ND	ND	ND	ND	ND	ND	ND	ND	
2-Hexanone	ug/l	0.010	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Ethetylbenzene	ug/l	0.010	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Methylnaphthalene	ug/l	0.010	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Cyclohexene	ug/l	0.020	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Trimethyldecane	ug/l	0.020	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Dimethylundecane	ug/l	0.020	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Bromodiodomethane	ug/l	0.020	ND	ND	ND	ND	ND	ND	0.036	0.10	0.12	

ND = Not detected. NR = Not requested.

ANALYTICAL RESULTS

for

South Adams County Water and Sanitation DistrictBedrock Wells - May 8, 1984

GROB CLOSED LOOP STRIPPING - TENTATIVE IDENTIFIED COMPOUNDS

Parameter	Units	Detection Limit	Well #4	Well #8	Well #1	Well #9	Well #11	Well #12	Well #13	Chlorinated Well #1
			3775-12	3775-13	3775-10	3775-14	3775-15	3775-16	3775-17	3775-11
Dichlorobenzene	ug/l	0.010	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorobenzene	ug/l	0.010	ND	ND	ND	ND	ND	ND	ND	ND
Propylbenzene	ug/l	0.010	ND	ND	ND	ND	ND	ND	ND	ND
C ₄ -Benzene	ug/l	0.010	ND	ND	ND	ND	ND	ND	ND	ND
Thiophene	ug/l	0.025	ND	ND	0.040	ND	ND	ND	ND	0.037
2-Hexanone	ug/l	0.010	ND	ND	0.023	ND	ND	ND	ND	ND
Ethylbenzene	ug/l	0.010	ND	ND	ND	0.66	ND	ND	ND	ND
Methylnaphthalene	ug/l	0.010	ND	0.010	ND	ND	ND	ND	ND	ND
Cyclohexene	ug/l	0.020	ND	ND	ND	0.13	0.073	ND	0.240	0.520
Trimethyldecane	ug/l	0.020	ND	ND	ND	ND	0.075	ND	ND	ND
Dimethylundecane	ug/l	0.020	ND	ND	ND	ND	ND	ND	0.032	ND
Bromodiodomethane	ug/l	0.020	ND	ND	ND	ND	ND	ND	ND	ND

ND = Not detected. NR = Not requested.

ANALYTICAL RESULTS

for

South Adams County Water and Sanitation District

Alluvial Wells - May 8, 1984

PESTICIDES

Parameter	Units	Detection Limit	Well #2 3775-01	Well #3 3775-02	Well #5 3775-03	Well #17 3775-08	Well #14 3775-04	Well #15 3775-06	Well #16 3775-07	Well #18 3775-09	Chlorinated Well #5/14 3775-05
1P Aldrin	ug/l	0.004	ND	ND	ND	ND	ND	ND	ND	ND	ND
2P alpha BHC	ug/l	0.003	ND	ND	ND	ND	ND	ND	ND	ND	ND
3P beta BHC	ug/l	0.006	ND	ND	ND	ND	ND	ND	ND	ND	ND
4P gamma BHC	ug/l	0.004	ND	ND	ND	ND	ND	ND	ND	ND	ND
5P delta BHC	ug/l	0.009	ND	ND	ND	ND	ND	ND	ND	ND	ND
6P Chlordane	ug/l	0.014	ND	ND	ND	ND	ND	ND	ND	ND	ND
7P 4,4'-DDT	ug/l	0.012	ND	ND	ND	ND	ND	ND	ND	ND	ND
8P 4,4'-DDE	ug/l	0.004	ND	ND	ND	ND	ND	ND	ND	ND	ND
9P 4,4'-DDD	ug/l	0.011	ND	ND	ND	ND	ND	ND	ND	ND	ND
10P Dieldrin	ug/l	0.002	ND	ND	ND	ND	ND	ND	ND	ND	ND
11P alpha Endosulfan	ug/l	0.014	ND	ND	ND	ND	ND	ND	ND	ND	ND
12P beta Endosulfan	ug/l	0.004	ND	ND	ND	ND	ND	ND	ND	ND	ND
13P Endosulfan sulfate	ug/l	0.066	ND	ND	ND	ND	ND	ND	ND	ND	ND
14P Endrin	ug/l	0.006	ND	ND	ND	ND	ND	ND	ND	ND	ND
15P Endrin aldehyde	ug/l	0.023	ND	ND	ND	ND	ND	ND	ND	ND	ND
16P Heptachlor	ug/l	0.003	ND	ND	ND	ND	ND	ND	ND	ND	ND
17P Heptachlor epoxide	ug/l	0.083	ND	ND	ND	ND	ND	ND	ND	ND	ND
18P PCB-1016	ug/l	0.04	ND	ND	ND	ND	ND	ND	ND	ND	ND
19P PCB-1221	ug/l	0.04	ND	ND	ND	ND	ND	ND	ND	ND	ND
20P PCB-1232	ug/l	0.04	ND	ND	ND	ND	ND	ND	ND	ND	ND
21P PCB-1242	ug/l	0.04	ND	ND	ND	ND	ND	ND	ND	ND	ND
22P PCB-1248	ug/l	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND
24P PCB-1260	ug/l	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND
25P Toxaphene	ug/l	0.24	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = Not detected. NR = Not requested.

ANALYTICAL RESULTS

for

South Adams County Water and Sanitation DistrictBedrock Wells - May 8, 1984

<u>Parameter</u>	<u>Detection</u> <u>Limit</u>	<u>Well</u> <u>#4</u>	<u>Well</u> <u>#8</u>	<u>Well</u> <u>#1</u>	<u>Well</u> <u>#9</u>	<u>Well</u> <u>#11</u>	<u>Well</u> <u>#12</u>	<u>Well</u> <u>#13</u>
		3775-12	3775-13	3775-10	3775-14	3775-15	3775-16	3775-17
	<u>Units</u>							
pH	units	8.57	8.47	8.55	8.40	8.54	8.48	8.55
Specific Conductance at 25°C	umhos/cm	371	373	411	449	341	290	295
Sodium	mg/l	78	64	100	84	81	62	69
Potassium	mg/l	0.40	0.92	0.62	1.2	0.78	0.50	0.72
Calcium	mg/l	3.1	15	2.2	17	1.8	2.3	2.8
Magnesium	mg/l	ND	1.5	ND	1.9	ND	ND	ND
Fluoride	mg/l	0.1	1.7	2.4	1.7	2.0	1.6	1.6
Chloride	mg/l	3.0	8.7	ND	13	3.2	3.1	ND
Bromide	mg/l	0.3	0.1	ND	0.1	ND	ND	ND
Nitrite as N	mg/l	ND	ND	ND	0.06	ND	ND	0.01
Nitrate as N	mg/l	ND	0.8	ND	1.2	ND	0.3	0.05
Ortho-Phosphate as P	mg/l	ND	ND	0.06	ND	0.06	ND	ND
Sulfate	mg/l	34	40	10.8	53	13.5	18.2	16
Total Alk. as CaCO ₃ at pH 4.5	mg/l	157	136	201	155	160	118	130
Total Cations	meq/l	3.6	3.7	4.5	4.7	3.6	2.8	3.2
Total Anions	meq/l	3.9	3.8	4.3	4.7	3.6	2.9	3.0
Difference	%	5.0	2.2	1.9	0.1	0.2	1.1	3.0

ND = Not detected. NR = Not requested.

ANALYTICAL RESULTS

for

South Adams County Water and Sanitation District

Bedrock Wells - May 8, 1984

TRACE METALS

Parameter	Units	Detection Limit	Well #4 3775-12	Well #8 3775-13	Well #1 3775-10	Well #9 3775-14	Well #11 3775-15	Well #12 3775-16	Well #13 3775-17
Aluminum	mg/l	0.05	ND	ND	ND	ND	ND	ND	ND
Antimony	mg/l	0.005	ND	ND	ND	ND	ND	ND	ND
Arsenic	mg/l	0.002	ND	ND	ND	ND	ND	ND	ND
Barium	mg/l	0.005	0.008	0.007	0.008	0.009	0.008	ND	ND
Beryllium	mg/l	0.001	ND	ND	ND	ND	0.008	ND	ND
Boron	mg/l	0.004	0.021	0.050	0.078	0.069	0.060	0.058	0.13
Cadmium	mg/l	0.002	ND	ND	ND	ND	ND	ND	ND
Calcium	mg/l	0.1	3.1	15	2.2	17	1.8	2.3	2.8
Chromium	mg/l	0.005	ND	ND	ND	ND	ND	ND	ND
Cobalt	mg/l	0.003	ND	ND	ND	ND	ND	ND	ND
Copper	mg/l	0.002	ND	ND	ND	ND	ND	ND	ND
Iron	mg/l	0.05	2.2	0.05	ND	0.38	ND	ND	ND
Lead	mg/l	0.025	ND	ND	ND	ND	ND	ND	ND
Magnesium	mg/l	0.1	ND	1.5	ND	1.9	ND	ND	ND
Manganese	mg/l	0.005	0.018	ND	ND	ND	ND	ND	ND
Mercury	mg/l	0.0002	ND	ND	ND	ND	ND	ND	ND
Molybdenum	mg/l	0.005	ND	ND	0.007	ND	ND	ND	ND
Nickel	mg/l	0.01	ND	ND	ND	ND	ND	ND	ND
Potassium	mg/l	0.3	0.40	0.92	0.62	1.2	0.78	0.50	0.72
Selenium	mg/l	0.002	ND	ND	ND	ND	ND	ND	ND
Silver	mg/l	0.003	ND	ND	ND	ND	ND	ND	ND
Sodium	mg/l	0.5	78	74	100	84	81	62	69
Strontium	mg/l	0.005	0.022	0.13	0.017	0.16	0.02	0.009	0.020
Thallium	mg/l	0.002	ND	ND	ND	ND	ND	ND	ND
Tin	mg/l	0.03	ND	ND	ND	ND	ND	ND	ND
Titanium	mg/l	0.002	ND	ND	ND	ND	ND	ND	0.003
Vanadium	mg/l	0.002	0.002	ND	ND	ND	ND	ND	ND
Zinc	mg/l	0.004	0.67	0.013	ND	ND	ND	ND	0.007

ND = Not detected. NR = Not requested.

ANALYTICAL RESULTS

for

South Adams County Water and Sanitation District

Alluvial Wells - May 8, 1984

TRACE METALS

Parameter	Units	Detection Limit	Well #2 3775-01	Well #3 3775-02	Well #5 3775-03	Well #17 3775-08	Well #14 3775-04	Well #15 3775-06	Well #16 3775-07	Well #18 3775-09
Aluminum	mg/l	0.05	ND	ND	ND	ND	ND	ND	0.06	ND
Antimony	mg/l	0.005	0.008	ND	ND	ND	ND	ND	ND	ND
Arsenic	mg/l	0.002	ND	ND	ND	ND	ND	ND	ND	ND
Barium	mg/l	0.005	0.056	0.066	0.051	0.075	0.075	0.062	0.043	0.077
Beryllium	mg/l	0.001	ND	ND	ND	ND	ND	ND	ND	ND
Boron	mg/l	0.004	0.22	0.24	0.11	0.056	0.28	0.31	0.25	0.13
Cadmium	mg/l	0.002	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	mg/l	0.1	172	175	162	130	154	175	157	144
Chromium	mg/l	0.005	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	mg/l	0.003	ND	ND	ND	ND	ND	ND	ND	ND
Copper	mg/l	0.002	ND	0.009	ND	ND	ND	0.045	ND	0.004
Iron	mg/l	0.05	0.05	ND	ND	ND	ND	0.23	0.096	0.07
Lead	mg/l	0.025	ND	ND	ND	ND	ND	ND	ND	ND
Magnesium	mg/l	0.1	20	21	19	16	20	31	20	18
Manganese	mg/l	0.005	ND	ND	ND	ND	ND	ND	ND	ND
Mercury	mg/l	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum	mg/l	0.005	ND	ND	ND	ND	0.011	ND	ND	ND
Nickel	mg/l	0.01	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	mg/l	0.3	5.2	5.7	5.2	4.4	8.2	7.2	6.2	4.8
Selenium	mg/l	0.002	0.004	ND	0.003	0.005	0.002	ND	ND	0.003
Silver	mg/l	0.003	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	mg/l	0.5	110	120	93	65	140	150	120	75
Strontium	mg/l	0.005	1.3	1.3	1.4	1.3	1.2	1.3	1.2	1.3
Thallium	mg/l	0.002	ND	ND	ND	ND	ND	ND	ND	ND
Tin	mg/l	0.03	ND	ND	ND	ND	ND	ND	ND	ND
Titanium	mg/l	0.002	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	mg/l	0.002	0.004	0.003	ND	0.002	0.003	0.004	0.003	0.004
Zinc	mg/l	0.004	0.010	0.027	ND	ND	ND	0.009	ND	0.004

ND = Not detected. NR = Not requested.

ANALYTICAL RESULTS

for

South Adams County Water and Sanitation DistrictAlluvial Wells - May 8, 1984

INORGANIC PARAMETERS

Parameter	Units	Detection Limit	Well #2 3775-01	Well #3 3775-02	Well #5 3775-03	Well #17 3775-08	Well #14 3775-04	Well #15 3775-06	Well #16 3775-07	Well #18 3775-09
pH	units	0.01	7.64	7.73	7.77	7.79	7.66	7.69	7.62	7.82
Specific Conductance at 25°C	umhos/cm	1	1440	1460	1260	963	1420	1610	1370	1110
Sodium	mg/l	0.5	110	120	93	65	140	150	120	75
Potassium	mg/l	0.3	5.2	5.7	5.2	4.4	8.2	7.2	6.2	4.8
Calcium	mg/l	0.1	172	175	162	130	154	175	157	144
Magnesium	mg/l	0.1	20	21	19	16	20	31	20	18
Fluoride	mg/l	0.1	0.7	0.7	0.7	0.8	0.7	0.8	0.8	0.8
Chloride	mg/l	3	111	112	89	64	114	141	111	90
Bromide	mg/l	0.1	0.8	0.8	0.7	0.6	0.8	0.9	0.7	0.6
Nitrite as N	mg/l	0.01	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate as N	mg/l	0.01	7.8	7.1	6.8	7.8	6.5	9.8	7.4	12.8
Ortho-Phosphate as P	mg/l	0.01	ND	ND	ND	ND	ND	ND	ND	ND
Sulfate	mg/l	5	340	350	340	210	340	360	320	210
Total Alk. as CaCO ₃ at pH 4.5	mg/l	5	295	334	213	210	289	340	290	237
Total Cations	meq/l	-	15	15	14	11	16	18	15	12
Total Anions	meq/l	-	17	17	14	11	17	19	16	13
Difference	%	-	4.8	5.4	1.8	1.0	2.9	2.7	4.1	2.1

ND = Not detected

**INORGANICS WATER
QUALITY DATA**

1696.0040 / 6.6.3

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DENVER

Inorganic

Water Quality Data

South Adams County Water and Sanitation District

JAMES M. MONTGOMERY
CONSULTING ENGINEERS, INC.

AREA	C&D	C&D	C&D	D	D	D	B
	TIS R66W Sec. 32 aadd	T2S R66W Sec. 19 ccdc	TIS R66W Sec. 31 badd	T2S R66W Sec. 5 bcdc	T2S R66W Sec. 7 abbc	TIS R66W Sec. 29 cac	T2S R67 Sec. 1 cccc
Aquifer	Alluvium	Alluvium	Alluvium	Alluvium	Surface Water	Alluvium	Alluvium
Depth (Ft)	16	14.5	40	48	—	45	42.5
Date	4/5/62	—	5/21/79	5/21/79	5/1/79	4/5/62	3/9/56
SiO ₂	20	14	—	—	—	22	—
Fe	(16)	—	—	—	—	.37	—
Mn	—	—	—	—	—	—	—
Ca	122	200	159	221	37.8	138	—
Mg	37	83	25.7	9.2	5.8	42	—
Na	100	365	209	288	28.0	136	—
K	4.2	5.7	4.37	6.2	3.3	3.4	—
HCO ₃	405	222	374	250	138	416	—
SO ₄	187	1,270	292	725	65	300	480
Cl	85	119	85	199	37	119	149
F	—	1.6	1.79	1.01	0.96	—	—
NO ₃	35	0.8	NR	18.8	1.84	2.0	—
B	—	0.42	—	—	—	—	—
TDS	789	2,170	—	—	—	957	—
Hardness	456	842	562	769	148	517	—
Non carbonate							
Hardness	124	—	—	—	—	176	—
Sodium Adsorption							
Ratio (S.A.R)	2.0	5.5	4.06	5.16	1.12	2.3	—
Specific Cond.							
(µmhos/cm)	1,240	2,870	1,980	2,470	430	1,500	1,820
pH	7.3	7.7	7.18	7.46	8.07	7.4	—
Source	1	1	2	2	2	1	1

All data reported in mg/L unless otherwise stated.

HRS Water Consultants

80112-04

January, 1986

Inorganic Water Quality Data
South Adams County Water and Sanitation District

Area	B T2S RCTW Sec 3 c bab	B T2S RCTW Sec 3 cccc2	B T2S RCTW Sec 11 b d d d	T2S RCTW Sec 11 d b d d 2	T2S RCTW Sec 12 a b d d	T2S RCTW Sec 13 c a d d	T1S RCTW Sec 28 c a d
Aquifer	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium
Depth (Fe)	12	10.8	56.3	50.0	30.8	40.5	50
Date	10/8/55	10/8/85	3/10/56	9/12/55	3/9/56	9/15/55	7/12/84
SiO ₂	24	26	—	23	—	35	—
Fe	—	—	—	—	—	—	1.07
Mn	—	—	—	—	—	—	—
Ca	134	136	—	128	—	122	—
Mg	31	33	—	37	—	75	—
Na	111	108	—	116	—	498	86
K	6.0	0.1	—	5.4	—	40	—
HCO ₃	325	296	—	460	584	1,710	—
SO ₄	246	220	633	134	17	15	183
Cl	106	144	111	130	220	194	—
F	1.6	1.2	—	1.2	—	1.4	—
NO ₃	46	30	—	32	0.6	0.5	2.18
B	0.25	0.22	—	0.26	—	0.67	—
TDS	866	845	—	833	—	1,820	761
Hardness	464	474	—	472	158	612	—
Noncarbonate Hardness	197	231	—	95	0	0	418
Sodium Adsorption Ratio (S.A.R)	2.2	2.2	—	2.3	—	6.8	—
Specific Cond (µmhos/cm)	1,340	1,370	2,000	1,380	1,580	3,030	1,245
pH	7.4	7.2	—	7.6	8.0	7.8	7.31
Source	1	1	1	1	1	1	3

All data reported in mg/L unless otherwise stated

HRS Water Consultants

80112-04

January, 1986

Inorganic Water Quality Data

South Adams County Water and Sanitation District

AREA	A		B					
	T1S R66W Sec 14 ac	T1S R66W Sec 14 ad	T2S R67W Sec 21 aaaa	T2S R67W Sec 9 dddd	T2S R67W Sec 11 bbe	T1S R67W Sec 25 cba	T1S R66 Sec. 32 dc	
Aquifer	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium	
Depth (FE)	—	—	—	—	—	—	—	
Date	6/27/83	7/1/83						
SiO ₂	—	—	—	—	—	—	—	
Fe	0.41	0.98	0.05	ND	0.1	0.05	ND	
Mn	0.03	0.03	0.009	ND	ND	ND	ND	
Ca	72	72	81	116	88	167	392	
Mg	34	29	16	30	25	33	138	
Na	97	95	100	130	96	120	350	
K	—	—	4.0	3.3	3.4	5.2	7.4	
HCO ₃	323 *	283 *	—	—	—	—	—	
SO ₄	159	179	69	190	140	270	1200	
Cl	92	97	110	140	69	130	380	
F	0.87	1.1	1.0	2.1	1.4	0.9	1.7	
NO ₃	31.1	16.8	1.0	6.0	5.3	2.8	33	
B	3.9	2.3	0.12	0.24	0.24	0.24	0.44	
TDS	688	776	—	—	—	—	—	
Hardness	366	350	—	—	—	—	—	
Non Carbonate Hardness	—	—	—	—	—	—	—	
Sodium Adsorption Ratio (S.A.R.)	2.36 *	2.39 *	—	—	—	—	—	
Specific Cond. (µmhos/cm)	900	950	886	1240	911	1370	3520	
pH	—	—	7.64	7.63	7.68	7.62	7.56	
Source	3	3	4	4	4	4	4	

ND = Not detected

All data reported in mg/L unless otherwise stated

* calculated from available data

HRS Water Consultants

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January, 1986

Inorganic Water Quality Data

South Adams County Water and Sanitation District

	T2S R66W Sec 5 bdd	T2S R66W Sec 5 aacc	T2S R66W Sec 6 dddd	T2S R66W Sec 5 bdb	T1S R66W Sec 32 ddaa	T1S R66W Sec 32 ddeb	T1S R66W Sec 32 dc
Aquifer	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium
Depth	—	—	—	—	—	—	—
Date	10/84	10/84	10/84	10/84	10/84	10/84	10/84
Temperature (°C)	12.5	16.25	12.5	12.0	16.5	12.5	17.5
Specific Cond. (µmhos/cm)	2,590	3,010	1280	3,280	880	2000	1200
SO ₄	1000	1125	500	820	155	515	325
NO ₃	14	18	5.4	7	5.1	20	10.1
Source	5	5	5	5	5	5	5

	T1S R66W Sec 32 dade	T1S R66W Sec 33 cdd
Aquifer	Alluvium	Alluvium
Depth	—	—
Date	10/84	10/84
Temperature (°C)	11.5	12.5
Specific Cond. (µmhos/cm)	500	3010
SO ₄	92	1,000
NO ₃	1.5	26.5
Source	5	5

All data reported in mg/L
unless otherwise stated.

Sources of Water Quality Data

- ① McConaghy, James A., et.al., 1964. Hydrogeologic data of the Denver Basin, Colorado: Basic Data Report No. 15, Colo. Water Conservation Board.
- ② Colorado Department of Health, 1973. water quality data from the Rocky Mountain Arsenal 360 water quality monitoring program.
- ③ Unpublished data, 1984. Beebe Draw Report.
- ④ Data from samples collected and tested by Rock Mountain Analytical, 1984.
- ⑤ HRS Water Consultants, 1984. field-collected data, Northwoods area

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January, 1986